PETROLEUM REFINER

WARREN'S

STABILIZED NATURAL GASOLINE *and* STA-VOL-ENE

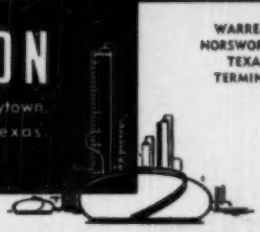
Ready for the Nation's Refiners

WARREN PETROLEUM CORPORATION

Producers, Manufacturers,
Exporters and Marketers;

Export Terminals: Corpus Christi, Port Arthur, Baytown, Texas City, and Norsworthy, Houston, Texas.

TULSA 2, OKLAHOMA CABLE ADDRESSES: Stavolene, Warren



WARREN'S NORSWORTHY, TEXAS TERMINAL

Crude Oil, Natural Gasoline and Liquefied Petroleum Products

"HOTTER, SOONER" Saves YOU MONEY

Yarway Impulse Steam Trap with new stainless steel body.

Yarway Impulse Steam Traps get equipment hot and into production *faster*. Extra profits!

Then they keep it *continuously* at peak operating temperatures for maximum production. More extra profits!

What's the reason for *hotter, sooner?* Just this. When steam is turned on, Yarways open wide, discharging the air and condensate *in a hurry* —closing only when steam arrives. Then, when operating temperature has been quickly reached, the little valve (only moving part) literally *floats on the load* . . . discharging heat-retarding condensate as soon as it forms instead of waiting for quantities to accumulate. Thus equipment is held at peak operating efficiency.

Other economical features of Yarway traps—minimum maintenance, easy installation, low initial cost.

More than 600,000 Yarways have already been installed. Sold by distributors throughout the world.

Try a Yarway today . . . standardize on Yarways tomorrow.

YARNALL-WARING COMPANY
128 MERMAID AVENUE, PHILA. 18, PA.

Nest of Yarway traps installed with Yarway Strainers on cloth dryer. Note small space required.

Stainless Steel Body

YARWAY IMPULSE STEAM TRAP

RAY L. DUDLEY, *Publisher*
WARREN L. BAKER, *Editorial Director*
L. S. DANIELS, *Editor*
SILAS B. RACSDALE, *Managing Editor*
C. C. PRYOR, *Associate Editor*
L. J. LOGAN, *Economics Editor*
HENRY OZANNE, *Eastern Editor*
DR. E. H. LESLIE, DR. H. B. COATS AND HEINZ HEINEMANN
Department Editors
CATHERINE GERMANY, *Editorial Assistant*
MARY E. ZUBER, *Librarian*

Specialized Oil Publications of
THE GULF PUBLISHING COMPANY
Box 2608, Houston (1), Texas

PETROLEUM REFINER and The REFINERY CATALOG
for the refining-natural gasoline industry

WORLD OIL (formerly The Oil Weekly)
and The COMPOSITE CATALOG
for the drilling-producing-pipe line industry

TOM W. NELSON, *Advertising Manager*
ROGER MOTHERAL, *Eastern Adv. Mgr.*

Advertising Representatives

NELSON BIGELOW
FRANK VICKREY
230 Park Ave.
New York 17, N. Y.

BILL WESTFALL
1010 Euclid Ave.
Cleveland 15, Ohio

H. G. FITZPATRICK
332 S. Michigan Ave.
Chicago 4, Ill.

BILL ATCHESON
Hunt Bldg.
Tulsa 3, Okla.

J. W. CURTS
W. W. Wilson Bldg.
Huntington Park, Calif.

CHARLES WYATT
3301 Buffalo Drive
Houston 6, Texas

Circulation Department
B. M. de SOMBRE, *Manager*

Single copies 50 cents (except special issues) for U. S. and Canada; $1 for all other countries. Subscription rates—U. S. and Canada $2 a year; Latin America $4 a year; overseas $10 a year. PETROLEUM REFINER, published every month, entered as second class matter June 18, 1923, at the post office at Houston, Texas, under act March 3, 1879. Advertising rates on application.

Copyright 1950 by Gulf Publishing Company.

Petroleum Refiner is indexed by Industrial Arts Index and by Engineering Index, Inc.

PETROLEUM REFINER

Specialized for Refining, Natural Gasoline and Petrochemical Engineering, Operation and Management

R. L. DUDLEY, President A. L. BURNS, General Manager

VOLUME 29, No. 10 OCTOBER, 1950

Contents

- **No Time Now for Political Manipulations and Socialistic Experiments** 63
  Criticism of certain Washington trends included in this survey of structure of the oil industry.
  A. L. Nicherson
- **A System of Process Calculations for Light Hydrocarbons** 83
  The first article of a series devoted to the simplification and organization of calculation methods for light hydrocarbon processing plants. The author has developed a set of computation forms that greatly expedite this work.
  A. & L. Hutchinson
- **Caltex Affiliated in Spain to Double Capacity of Plant** 90
  Cartagena refinery of 20,000 barrels per day capacity will have facilities for crude oil distillation, thermal reforming, catalytic polymerization, and lubricants manufacture.
- **Influence of Exhaust Back Pressure on Antiknock Performance of Aviation Fuels** 91
  Compound power plants utilizing both reciprocating engines and free gas turbines are expected to play a considerable part in our aviation fuels field in the immediate future.
  W. E. Morris
- **Planning Refinery Heat Transfer Equipment, Part II. Efficiency and Operating Relations** 95
  Equipment efficiencies and operating conditions deserve careful attention because they directly influence annual operating costs.
  Tyler G. Hicks
- **Synthetic Liquid Fuels—Status of Development in the U. S.** 99
  The government's program of synthetic fuels research and development has been under way since 1944. The program, originally planned for a five-year term, has been extended to include an eight-year period. Total authorized expenditure is sixty million dollars. All laboratories are now active and the lead demonstration plant recently completed.
  Harold L. Silcox
- **Forces in Pipe Bends from Expansion** 103
  It is not an uncommon sight around process plants to see nozzles deflected, flanged connections leaking, safety valves lifted, and pump blocks displaced. Under such misalignment conditions, plant operation is neither as smooth or as safe as is desirable. To avoid such difficulties, piping must be designed with provision for the effects of thermal expansions.
  F. K. Woloszwick
- **Multicomponent Vapor-Liquid Equilibrium Calculations Made by Punch Card System** 109
  A rapid and accurate procedure for working out hydrocarbon equilibrium conditions by the use of standard accounting machines.
  J. W. Donnell and Kenneth Turbin
- **Removable Insulation for Refinery Vessels** 112
  A system installation especially suitable for the insulation of process plant pressure vessels subject to severe operating conditions.
  Marshall F. Allen
- **Endpoint Determinations Are Sharply Influenced by Test Variations** 114
  The author records some of the factors that affect the accuracy of this much used specification.
  George H. Hagstrom
- **Distillation Column Balance—The Overhead-Bottoms Split vs. the Feed Composition** 117
  A study of distillation column factors that may well lead to improvements in the instrumentation and operation of commercial units.
  W. D. Harbert
- **The Fugacity of Propene and 1-Butene** 123
  The increasing utilization of conversion processes in refineries and gasoline plants requires engineers to make calculations involving olefins and utilizing data on the volumetric and phase behavior of these hydrocarbons.
  B. H. Sage and W. N. Lacey
- **Skelly Revises Schaefer Plant for Increased Production** 128
  Modernized plant processes 11,500,000 cubic feet daily of natural gas for the production of some 75,000 gallons of liquid products.
- **Catalytic Cracking, Part III** 130
  The history and present status of the fluid catalytic cracking process.
  Marshall Sittig

DEPARTMENTS

The Look Box 59
Refinery and Other Plant Construction 71
Refiner Authors and Other Personalities 138
How to Do It 143
The Month in the Industry 149
The Oil Man's Calendar 153
Science and Technology Abstracts 165
Compiled by Dr. E. H. Leslie and Dr. H. B. Coats
Digest of United States Patents Pertaining to Petroleum 177
Compiled by Heinz Heinemann
New Equipment, Manufacturers' Literature 193
Book Reviews 214
About Equipment and Service Suppliers 218
Index to Advertisers 230

MODERATELY PRICED SMALL STEEL VALVES FROM THE COMPLETE CRANE LINE

UNION BONNET GATES . . . MORE COMPACT, MORE RUGGED

Here's a valve value made possible by Crane Co.'s finer facilities for *quality* mass production. These low-cost, small steel gates are specially designed for a wide range of tough services in petroleum processing, in oil and gas fields. They readily withstand rough usage, piping and pressure strains, and extreme variations in temperature. The features below show how and why they do it.

COMPACT OVERALL DESIGN—size for size, these valves are more compact than the usual high-pressure design—at no sacrifice of strength.

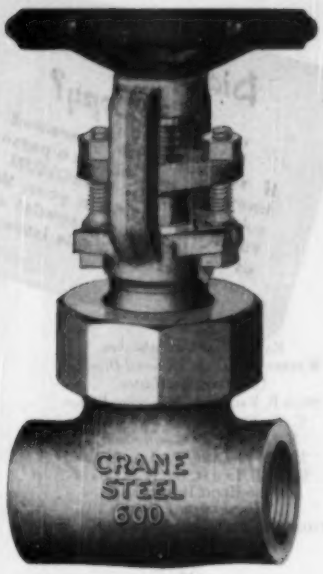
TIGHT UNION BONNET JOINT—heavy steel union ring with long, precision-cut threads pulls up easily, stays tight, protects against distortion when joint is opened. Male and female bonnet joint with soft iron gasket eliminates possibility of gasket blowout.

LEAKPROOF BODY SEAT RINGS—are securely rolled into the body. No danger of leakage around ring. Cannot loosen in service.

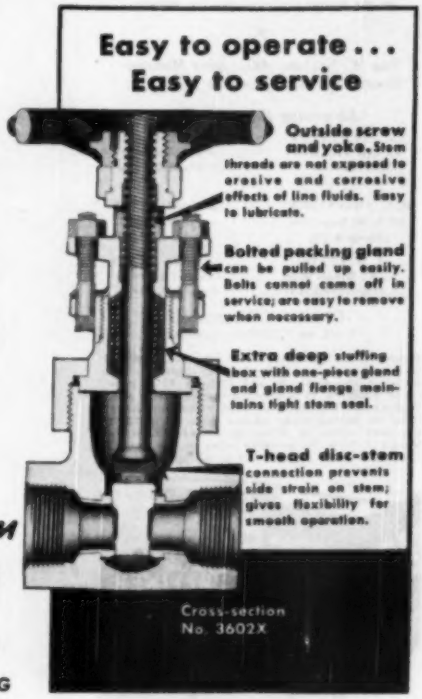
FULLY GUIDED SOLID WEDGE DISC—cannot get out of line or jam in body. Disc drag and wear on seating surfaces are minimized.

GET DESCRIPTIVE FOLDER AD-1741 for more data on these valves. Gives sizes, dimensions, and service recommendations. Ask your Crane Representative for a copy or write direct. These valves also listed in your Crane No. 49 Catalog, P. 223.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas



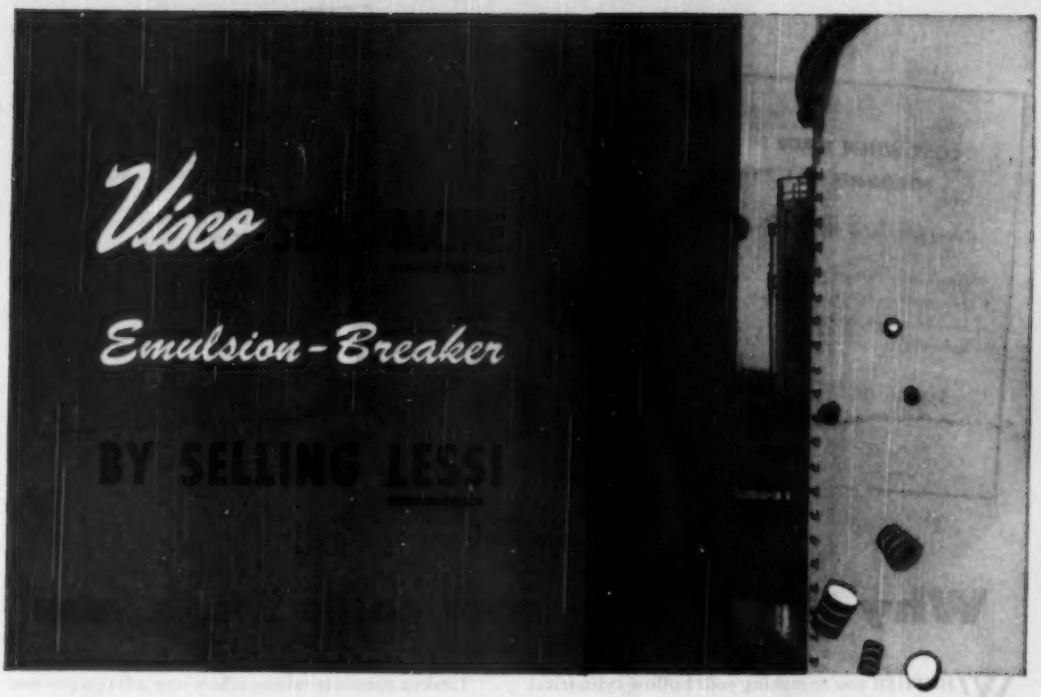
No. 3602X, 600-Pound Small Steel Gate for oil or oil vapor up to 1000° F. Exalloy to Exalloy seating. Sizes: ¼ to 2-inch. Screwed or welding ends.


Easy to operate . . .
Easy to service
Outside screw and yoke. Stem threads are not exposed to erosive and corrosive effects of line fluids. Easy to lubricate.
Bolted packing gland can be pulled up easily. Bolts cannot come off in service; are easy to remove when necessary.
Extra deep stuffing box with one-piece gland and gland flange maintains tight stem seal.
T-head disc-stem connection prevents side strain on stem; gives flexibility for smooth operation.
Cross-section No. 3602X

EVERYTHING FOR EVERY PIPING SYSTEM

CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING



● **Treating cost per barrel of *acceptable* dry oil is the true measure of emulsion-breaker efficiency . . . And the Visco formula that requires the least chemical to do the best job is the one for your lease. Visco's service records show that we can sell *more* emulsion-breaking and dehydrating chemicals by selling *less!* Visco's sales records prove it.**

Proof is as close as the nearest phone. Call Houston, CAPITOL 7300, collect, for service that matches Visco's fast, efficient emulsion-breaking.

VISCO PRODUCTS COMPANY
INCORPORATED
City National Bank Building
Houston 2, Texas

A NEW VISCO PRODUCT!

Visco VS SOLVENT

Visco VS was developed for our own use as a high-flash-point solvent for wax, grease, lube oils, paint, oil-treating chemicals, and fusible or soft resins. It is so good, it has been made available to the whole petroleum industry! Will not harm skin, wood or metal. Available now. Write or call for full details and prices.

Visco... CONSISTENTLY EFFICIENT DEHYDRATING AND DESALTING CHEMICALS

NOTICE: Visco Products Company is authorized to manufacture and sell Visco Oil Treating compounds for use in the breaking and resolving of oil emulsions, and to grant licenses for such use, under the following United States patents: 1,884,103; 1,884,845; 1,911,330; 1,917,359; 1,936,939; 1,936,940; 2,250,589; 2,314,788; 2,314,796; 2,320,169; 2,363,414; 2,387,841; 2,410,930; 2,410,931; 2,511,464; 2,520,334; Re 20,727 and patents pending. Any purchaser of Visco Oil Treating compounds is authorized to use the same in the treating, breaking and resolving of oil emulsions in accordance with the above patents for such use is included in the purchase price. Visco Products Company is authorized to and is willing to grant licenses on a royalty basis, to all companies, and to others desiring an exclusive the patented subject matter, under any and all of the above patents, permitting the user to purchase the oil treating compounds as it may from any vendor, and to prepare the compounds for use under the above patents or patents, at a royalty charge of 20 cents per gallon. Application for license should be made to Visco Products Company, Houston, Texas.

COST WHEN MADE FROM FORGINGS—$1.714

Cost of forging per unit . . **$0.4228**

Production cost per unit (broached and then machined on chucking automatic) **$1.2912**

TOTAL COST PER UNIT—$1.714

COST WHEN MADE FROM TIMKEN TUBING—$1.47

Cost of tubing per unit . . **$0.293**

Production cost per unit (with mill-length tubing on 4-spindle 5" capacity automatic screw machine) **$1.177**

TOTAL COST PER UNIT—$1.47

Why this sleeve now costs 24.4¢ less

WHETHER you're making your hollow cylindrical parts from forgings or bar stock, chances are you can save money by switching to Timken® seamless tubing. For example, by using Timken tubing in place of forgings for the sleeve part shown here, the manufacturer cut his costs from $1.714 to $1.47 per piece.

This saving was possible for two reasons: 1. Unit for unit, Timken seamless tubing was far less expensive than forgings. 2. The mill lengths of tubing could be broached and machined on an automatic screw machine, whereas the forgings had to be broached and then maintained on a chucking automatic. The saving was so great that the cost of the new screw machine and tooling —$33,000—was more than paid for during the first year. The tables above give you the actual cost breakdowns.

Timken seamless tubing offers cost advantages over bar stock as well as forgings. The hole is already there. You can often start right in with finish boring. Scrap loss is reduced—machining time saved.

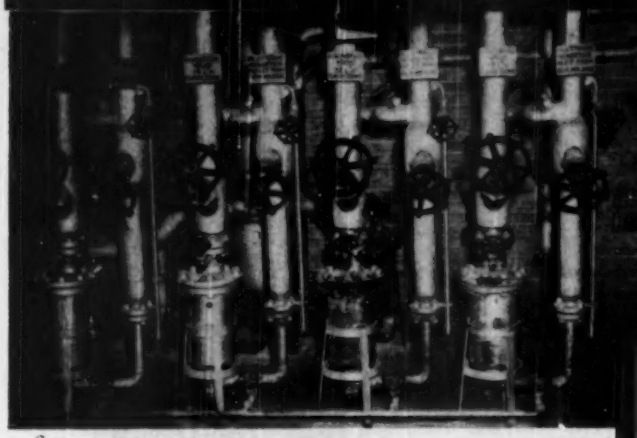
And you get better quality too. The piercing process by which Timken tubing is made is basically a forging operation, resulting in greater product strength. From tube to tube and heat to heat, this fine forged quality is always uniform, thanks to Timken's rigid controls.

OUR TUBE ENGINEERING SERVICE will choose the most economical size tube for you . . . guaranteed to clean up to your finish dimensions. Write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.

steam traps



List of Materials

CAP and BODY FORGINGS: *
Up to 600 psig—S.A.E. 1030 steel
600 to 900 psig—ASTM F-1 moly-steel
900 to 1500 psig—ASTM F-7 chrome moly-steel

VALVE AND SEAT:
Chrome steel, heat treated

BUCKET and VALVE LEVER ASSEMBLY:
18-8 Stainless Steel

BOLT and NUT SET: *
Bolts Class C, 125,000 lbs. tensile
Nuts, hex, semi-finish, S.A.E. 1030

GASKET: *
Compressed graphited asbestos

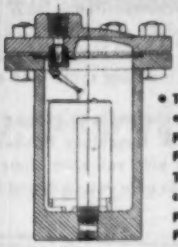
*Does not apply to No. 3211 nor No. 913

1. **FOR HIGH PRESSURE SERVICE** — engineers responsible for the design or operation of high pressure, high temperature steam plants can specify with confidence Armstrong Forged Steel Steam Traps to provide completely automatic condensate drainage throughout. These traps are "standard" in leading power stations throughout the entire world where they are used for draining headers, desuperheaters, soot blowers and other drip points at pressures as high as 2400 psig! These traps always open when filled with condensate and there is no steam loss under no-load conditions. Safety and dependability are assured through use of modern materials, highest quality workmanship and critical inspection.

2. **FOR ALL-STEEL INSTALLATIONS** — Armstrong Forged Steel Traps also ideally meet the increasing demand in power plants, refineries and general industry for all-steel fittings on lower pressures (up to 250 psig) because they are light in weight and surprisingly low in price. They provide the maximum in safety, dependability, shock and fire resistance.

● FOR COMPLETE DATA ask for the 36-PAGE ARMSTRONG STEAM TRAP BOOK or see our catalog in Sweet's.

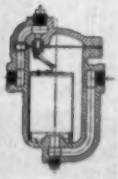
ARMSTRONG MACHINE WORKS
852 Maple Street, Three Rivers, Michigan



● **Traps with screwed connections for pressures to 900 psig.**

Traps with flanged connections for pressures to 2400 psig.

● **No. 3211 trap for pressures to 250 psig, only $14.00.**



● **Side inlet cast steel trap for pressures to 600 psig, screwed or flanged connections.**

ARMSTRONG STEAM TRAPS

How **B&W**
INSULATING FIREBRICK
Trim Processing Costs

Four *key* words explain how B&W Insulating Firebrick lower over-all costs in chemical and petroleum process furnaces:

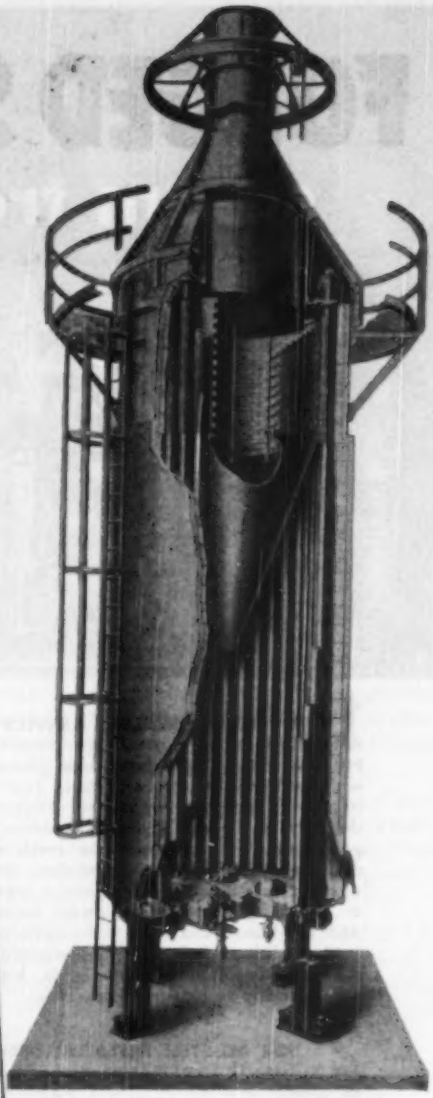
SHORT—You can *shorten* installation time materially with B&W Insulating Firebrick because they can be cut, drilled or shaped on the job with ordinary woodworking tools.

LONG—B&W Insulating Firebrick are *long* lasting because of the exceptional refractory nature of their base ingredients and the high processing temperatures to which they are subjected during manufacturing.

HIGH—These lightweight brick have *high* insulating values . . . may be supported with ordinary carbon steel hangers. You don't have to use expensive, heat-resisting alloys.

LOW—These cost-cutting brick have the *lowest* heat storage of any insulating firebrick. Since B&W Insulating Firebrick cool off fast, they reduce down-time . . . make possible quick access to the furnace for inspection. They also reach operating temperature quickly, reducing cycle time and fuel bills.

These are four sound reasons why process furnace builders and operators specify B&W Insulating Firebrick. Learn how these lightweight brick can help you save money. Your B&W representative will be glad to give you facts and figures.



Sectional View of Petro-Chem Development Company Iso-Flow Furnace lined with B&W Insulating Firebrick.

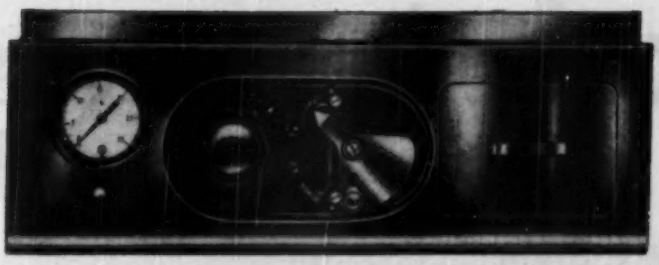
Four Petro-Chem Iso-Flow Furnaces installed in large southwestern oil refinery.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 85 LIBERTY ST., NEW YORK 6, N.Y.
WORKS: AUGUSTA, GA.

R-500

B&W REFRACTORIES PRODUCTS—B&W 90 Firebrick • B&W Junior Firebrick • B&W 80 Glass Tank Blocks • B&W Insulating Firebrick B&W Refractory Castables, Plastics and Mortars • OTHER B&W PRODUCTS—Stationary & Marine Boilers and Component Equipment... Chemical Recovery Units . . . Seamless & Welded Tubes . . . Pulverizers . . . Fuel Burning Equipment . . . Pressure Vessels . . . Alloy Castings



No other control instrument

has an external manual-automatic station as mistake-proof as this

EXCLUSIVE mechanical interlock prevents switching into wrong position

EXCLUSIVE "balancing" arrangement prevents "bumping" on changeover

Among the many features which have put the Bristol Series 500 Air-Operated Controller way out front is the unique External Manual-Automatic Station.

1. "Test" and "Service" positions are mechanically interlocked. Operator cannot, by mistake, go *through* "Manual" position into either "Test" or "Service."

2. Output pressures of the controller and the regulator on panel are measured by the *same* gauge. This enables operator to achieve exact *balance* before going from automatic to manual control or vice versa, thus eliminating the possibility of a "bump" to the process during changeover.

Bristol's External Manual-Automatic Station is an integral part of the controller installation . . . yet can be used independently for manually controlling the process *before* the controller is installed or *after* it has been removed for any reason.

Read what else Bristol Series 500 Controller gives you . . . calibrated control, single service adjustment, reset stops, etc. Write for new Bulletin A120 on Series 500 Air-Operated Controllers, THE BRISTOL COMPANY, 111 Bristol Road, Waterbury 20, Conn.

BRISTOL

Engineers process control for better products and profits

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

A "good chemical neighbor" policy can start at the sewer—

This is the Micromax pH control panel for use in waste neutralization. It can be installed by the plant electrician or instrument man.

The sewer outfall marks the spot where a plant can prevent stream pollution, by discharging only wastes which have been properly treated. And, when proper treatment is linked to pH control, we can probably help . . . effectively. We can assist engineers to set up good "chemical relations" between a company and the rest of the community . . . make the plant a good chemical neighbor.

Our contribution is through Micromax automatic pH control. Correct pH is often the definite assurance that plant wastes are meeting the requirements of good stream chemistry. We can tell you in just a few minutes whether pH on your waste neutralization system—either a present system or a contemplated one—can be controlled automatically: whether you can hold pH within prescribed limits.

Controllability analysis predicts actual results. Through long experience with pH control applications, we have developed a unique system of "controllability analysis." By scientifically weighing all pH control factors—type of waste, treating system, reagent—this analysis determines the net control effect possible for a given treating system.

If you're planning pH control, you can't afford to miss this special service. Our catalog "Effective Neutralization of Industrial Wastes" explains controllability analysis in full detail. For your convenience, it also contains a simple questionnaire . . . so we can help you begin solving your plant's pH problems now. You can answer the questions in just a few minutes.

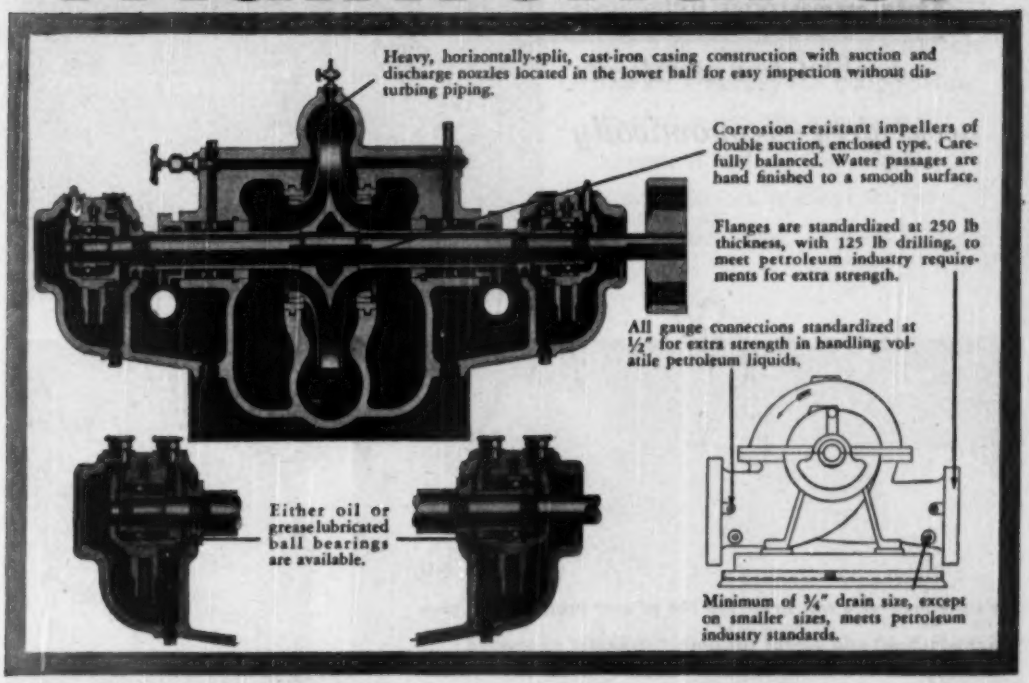
Ask for Bulletin ND44-96-708. Address Leeds & Northrup Company, 4923 Stenton Avenue, Philadelphia 44, Pa.

MEASURING INSTRUMENTS • TELEMETERS • AUTOMATIC CONTROLS • HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl Ad ND44-96-708(2)

Designed for Low Maintenance


Heavy, horizontally-split, cast-iron casing construction with suction and discharge nozzles located in the lower half for easy inspection without disturbing piping.
Corrosion resistant impellers of double suction, enclosed type. Carefully balanced. Water passages are hand finished to a smooth surface.
Flanges are standardized at 250 lb thickness, with 125 lb drilling, to meet petroleum industry requirements for extra strength.
All gauge connections standardized at ½" for extra strength in handling volatile petroleum liquids.
Either oil or grease lubricated ball bearings are available.
Minimum of ¾" drain size, except on smaller sizes, meets petroleum industry standards.

THE DEMAND FOR LOW MAINTENANCE pumps for the petroleum industry has steadily increased. To serve this specific need, Allis-Chalmers offers a *complete* line of Type S, single stage, double suction pumps, individually engineered to meet your specifications.

All parts are precision machined and carefully assembled. Heavy construction plus proper alignment of pump parts assure long life of wearing rings, sleeves, packing and bearings. Impeller and shaft are carefully balanced. Impeller clearances are accurately measured to cut recirculation losses.

Although the most common drives for centrifugal pumps are Allis-Chalmers squirrel cage induction motors, Allis-Chalmers also supplies a complete line of induction, synchronous and direct current motors, and gasoline engines of the generally used sizes for most pumping applications.

For complete information on Allis-Chalmers pumps and drives, contact your nearby A-C Sales Office, or write direct for Bulletin 08B6146A.

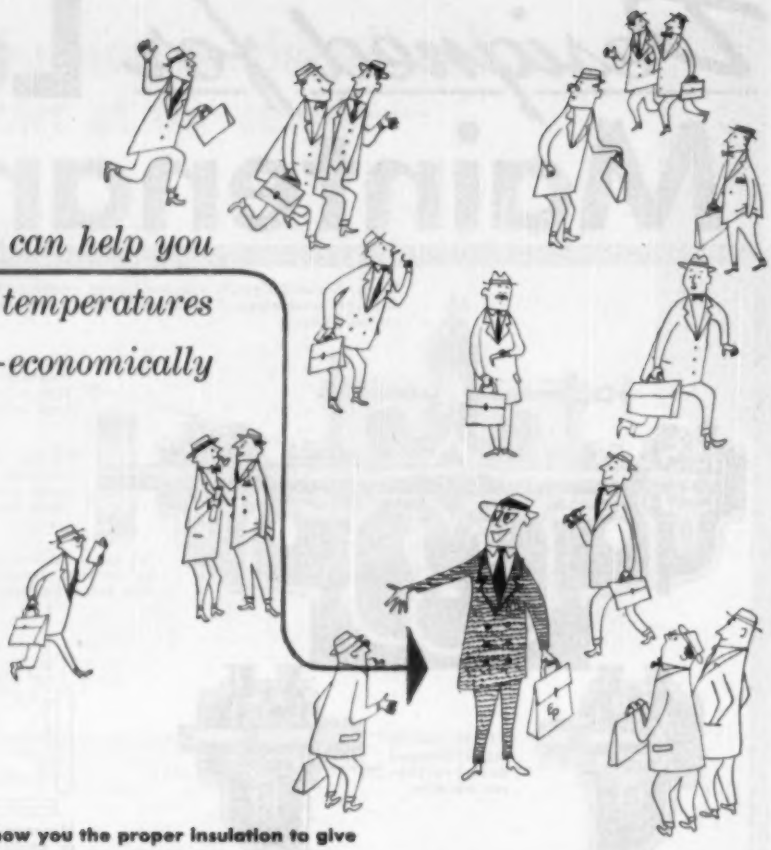
A-3137

ALLIS-CHALMERS, 1062A SO. 70 ST.
MILWAUKEE, WIS.

ALLIS-CHALMERS

Texrope is an Allis-Chalmers trademark.

Power, Electrical, Processing Equipment for Petroleum Industry



This man *can help you*

control temperatures

accurately—economically

He's the man who can show you the proper insulation to give maximum heat and power for each fuel dollar expended

An Eagle-Picher Industrial Insulation distributor or representative can help you reduce operating expenses because he has available a wide line of insulation products—for high and low temperatures—scientifically designed for maximum thermal efficiency, and practical application. Why not let him give you more information about some of the products listed here?

These Eagle-Picher products can save you money . . . power . . . time

Insulating Felts • Supertemp Blocks • Blankets • Loose Wool Pipe Covering • Stalastic • Insulseal • Insulstic • Swetchek Finishing Cements • Insulating Cements • Fireproofing Cement Diatomaceous Earth Blocks

EAGLE EP PICHER

Since 1843

THE EAGLE-PICHER COMPANY

General Offices: Cincinnati (1), Ohio

Insulation products of efficient mineral wool — for a full range of high and low temperatures. Technical data on request.

Here's a new product that will save you money

EAGLE-PICHER FIREPROOFING CEMENT

Can be mixed with water to form a stiff plastic mix for easy application on ribbed lath. Recommended for fireproofing structural steel columns, steel tank supports, skirts and equipment bases. Has high dry coverage of approximately 30 sq. ft. 1 inch thick per 100 pounds. Adds fire protection, patented rust inhibitor resists corrosion. Tested by Underwriters' Laboratories, Inc.

These efficient, versatile insulations "team up" to give perfect insulation for every major application

For a completely effective, low-cost insulation combination, you can't beat the teamwork of Eagle-Picher Mineral Wool Blankets, Supertemp Blocks, Diatomaceous Earth Blocks and Earth Fill, and Super "66" Cement. They work effectively to give your equipment highest possible thermal efficiency . . . cut operating costs by saving the maximum amount of fuel . . . and help to provide perfect, precise control over temperatures.

EAGLE-PICHER SUPER "66" INSULATING CEMENT

Super "66" is all-purpose, rust-inhibitive, extremely adhesive insulating cement. "Springy ball" pellets don't collapse after application . . . give great coverage, retain their thermal efficiency. 100 lbs. covers 65 sq. ft.—1 inch thick. Easily applied with trowel, over flat and irregular surfaces. Efficient for temperatures up to 1800° F. Reclaimable when used on equipment whose temperatures do not exceed 1200° F.

EAGLE-PICHER SUPERTEMP BLOCKS

Eagle-Picher Supertemp Blocks are lightweight (approximately 16 lbs. per cu. ft.). Can be cut easily with knife or saw to fit off-shaped areas . . . they fit snugly over minor irregularities. They're strong and have high refractory value. Withstand temperatures up to 1700° F. Conductivity at 512° F. approximately 0.43 . . . all standard sizes, from 3"x18" to 12"x36" in thicknesses from 1" to 4".

EAGLE-PICHER MINERAL WOOL BLANKETS

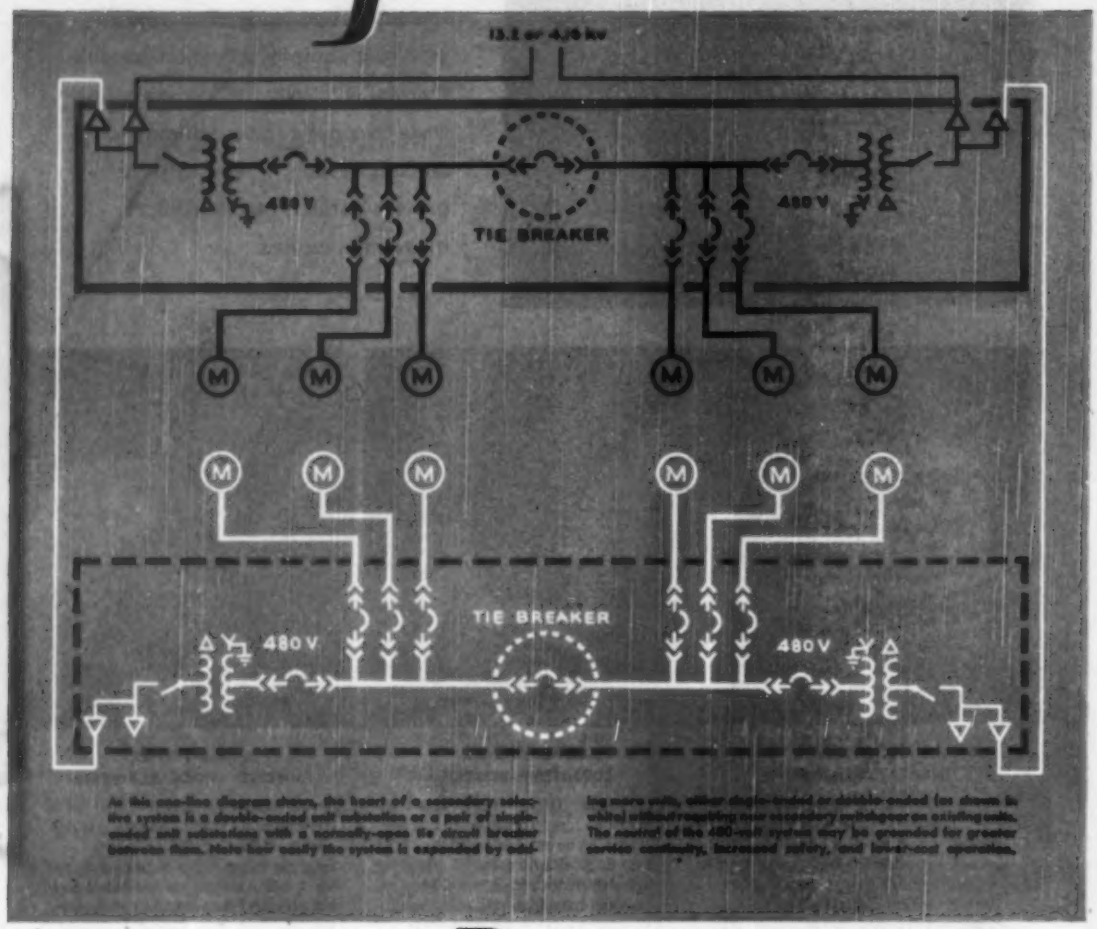
These blankets satisfy the need for a convenient method of quickly and efficiently insulating flat or curved surfaces on larger types of heated equipment. Mineral wool is felted and secured between flexible metal fabric. Outstanding physical and chemical stability enables Eagle-Picher Blankets to resist water steam, corrosive fumes and normal vibration.

THE EAGLE-PICHER COMPANY General Offices: Cincinnati (1), Ohio

Insulating Felts • Supertemp Blocks • Blankets • Loose Wool • Pipe Covering
Stalastic • Insulseal • Insulstic • Sealtchek • Finishing Cements
Insulating Cements • Fireproofing Cement • Diatomaceous Earth Blocks

What's the trend in refinery electrification?

secondary



As this one-line diagram shows, the heart of a secondary selective system is a double-ended unit substation or a pair of single-ended unit substations with a normally-open tie circuit breaker between them. Note how easily the system is expanded by adding more units, either single-ended or double-ended (as shown in white) without requiring new secondary switchgear on existing units. The neutral of the 480-volt system may be grounded for greater service continuity, increased safety, and lower-cost operation.

Here's what you need to modernize your power system!

WHEN YOU COME TO GENERAL ELECTRIC you get far more than the finest in electrical equipment. A General Electric application engineer, familiar with refinery practices, is at your disposal. If desired, he stands ready to assist you in co-ordinating all the needed components, engineering your power distribution into one modern, efficient system.

selective distribution systems

WITH UNIT SUBSTATIONS

—to protect continuity of service at minimum cost

What's behind the growing refinery practice of distributing power through secondary selective systems? Primarily it's recognition of the fact that for most plants it provides a simple, low-cost way to safeguard service continuity for operations requiring uninterrupted production.

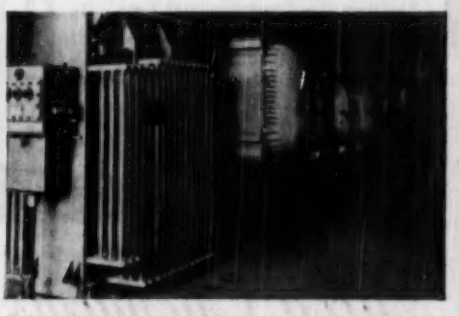
This method utilizes a normally-open tie circuit breaker between the secondaries of two transformers in a double-ended unit substation. The tie provides an alternate source of power for secondary circuits if either transformer becomes de-energized by a fault in the primary circuit. In effect, it enables one "partner" when necessary to carry the essential load.

Simplicity is another advantage of this system. Operating personnel need no special training to operate and maintain the equipment contained in a double-ended unit substation—chiefly transformers and manually-operated drawout air circuit breakers.

Moreover, expansion is easy and economical. Single-ended or double-ended substations can be added at will. Since no added interrupting duty is imposed, no new secondary switchgear is needed on existing units. Full data is contained in Bulletin GET-1438, "Secondary Networks for Industrial Plants." Send for your copy today. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

TO HELP CUT YOUR POWER DISTRIBUTION COSTS . . . Don't miss seeing the "More Power to America" full color and sound slide-film "Modern Industrial Power Distribution." It's packed with helpful, cost-cutting ideas you can use. Ask your G-E representative to arrange a showing for your organization.

G-E double-ended load-center unit substations for non-hazardous areas are compact, factory-assembled "packages." Shipped ready to install, they are furnished in flexible combinations of incoming-line and secondary-circuit arrangements with transformers from 100 to 2000 kva.



For semi-hazardous areas, G-E double-ended load-center unit substations have easily removable air circuit breakers, each in Class I, Group D enclosures, plus primary power circuit breaker, a standard Pyranol (R) transformer section, and a secondary bus enclosure.

GENERAL ELECTRIC

660-32

GULF OIL CORPORATION

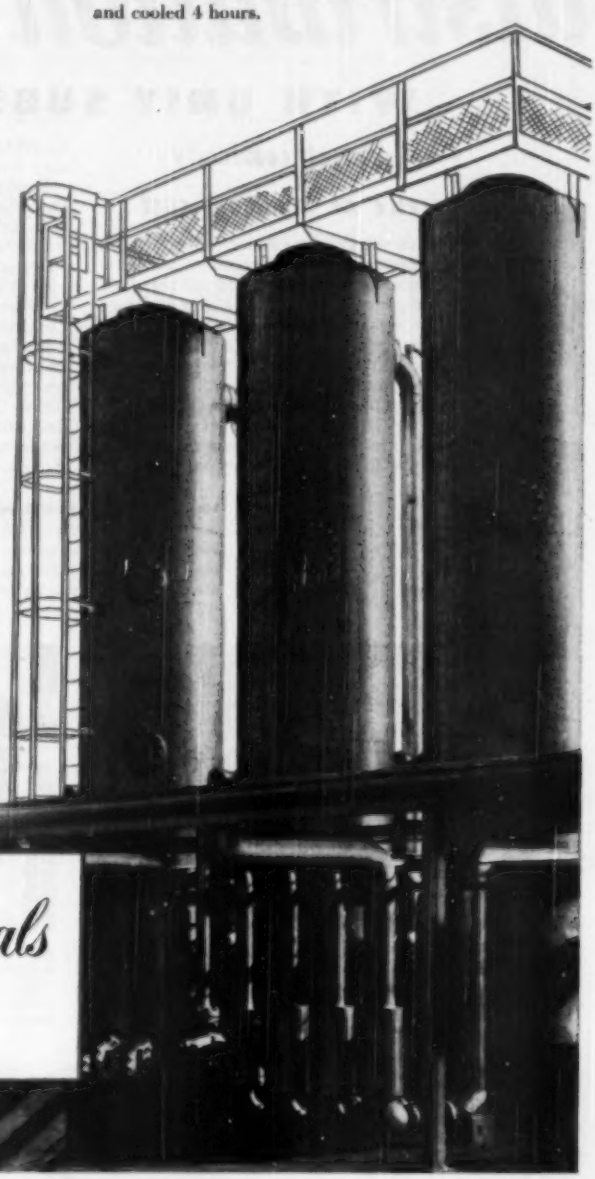
USES ALCOA

ACTIVATED* ALUMINA

IN AUTOMATIC

3-TOWER DEHYDRATOR

Gulf Oil Corporation's 3-tower dehydrator unit at Eunice Gasoline Plant, Eunice, New Mexico. Drying 32,000,000 standard cubic feet of residue gas per day to dew points *well below 0° F.*, the unit permits each tower to be on stream 4 hours, reactivated 4 hours and cooled 4 hours.



This unique 3-tower dehydrator unit is entirely automatic, except for an occasional dew point check.

In such a system, the *reliability* of the desiccant is highly important—a good reason for choosing ALCOA *Activated* Alumina. It is one of the few solid-type drying agents that will not change its form or properties. It will not swell, soften or disintegrate even when immersed in water.

ALCOA *Activated* Alumina is non-corrosive and practically iron-free. It is not affected by shock or abrasion, and has no effect on the end product even when the two stand in contact for long periods. It is a uniformly pure desiccant that dries liquids and gases to a lower dew point than any other commercial adsorbent.

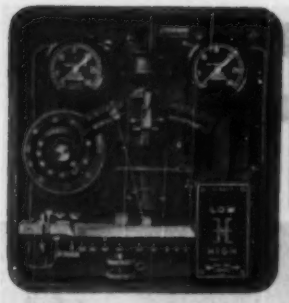
Let us send you the booklet "Activated Alumina—Its Properties and Uses." Its 48 illustrated pages describe the properties and applications of ALCOA *Activated* Alumina. Write to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 617K Gulf Building, Pittsburgh 19, Pa.

*Reg. T. M., *Aluminum Company of America*

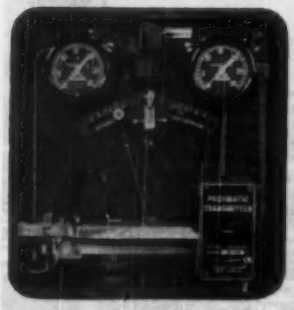
Alcoa Chemicals

ALCOA ALUMINAS and FLUORIDES

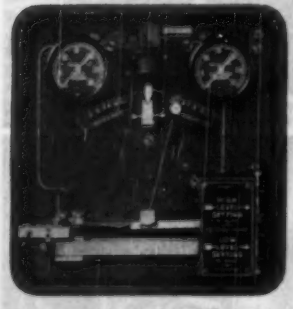
ACTIVATED ALUMINAS • CALCINED ALUMINAS • HYDRATED ALUMINAS • TABULAR ALUMINAS • LOW SODA ALUMINAS ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUORBORIC ACID • CRYOLITE • GALLIUM



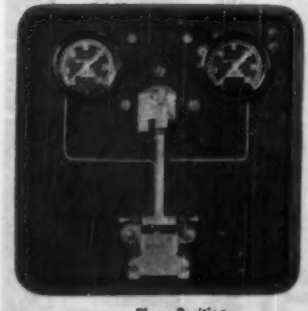
12610 Proportional-Reset Controller



12620 Pneumatic Transmitter



12630 Two-Position Differential-Gap Controller



12000-15 Three-Position Pneumatic Signal Switch

Versatility + *in the* 12,000 Series

LEVEL CONTROLLER MECHANISMS

The **12000** Series Level Controllers (variable displacement) are available in a wide range of models designed to meet the requirements of specific applications. Incorporated in the four models illustrated are the basic mechanisms of the series.

The **12610** Proportional plus Reset Controller is used when maximum vessel surge capacity is wanted at all times in the presence of sustained load changes. It combines proportional-position action with proportional-speed floating action.

The **12620** Pneumatic Transmitter transmits level in terms of output pressure to any type remote receiver, or to a pneumatic switch for the operation of signal lights or other electrical devices. It has proportional-position action with 100% proportional band.

The **12630** Two-Position Differential-Gap Controller meets process requirements where proportional action is undesirable or to reduce wear on a valve or pump resulting from continuous or frequent operation. It combines two-position action with differential-gap.

The **12000-15** Three-Position Pneumatic Signal Switch Controller provides remote indication or control of level by actuating signal lights or other electrical devices when either of two predetermined limits is reached. It has three-position indication or on-off control.

CONTROLLER MOUNTINGS

Mountings for the 12000 Series controller are equally flexible; easily adapted to unusual or special vessel requirements with a wide selection of type, material, chamber rating and level ranges.

MASONEILAN

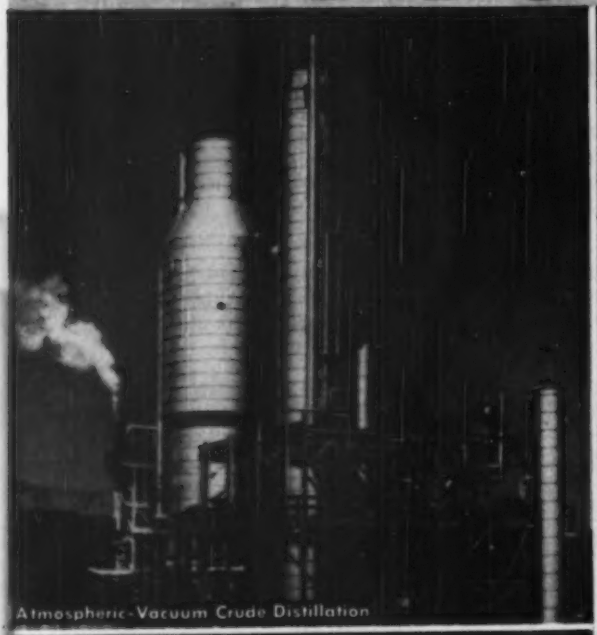
Mason-Neilan Regulator Company

1182 ADAMS STREET, BOSTON 24, MASS., U. S. A.

Sales Offices or Distributors in the Following Cities: New York • Syracuse • Chicago • St. Louis Philadelphia • Houston • Denver • Pittsburgh • Cleveland • Cincinnati • Tulsa • Atlanta Los Angeles • San Francisco • Salt Lake City • El Paso • Boise • Albuquerque

Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

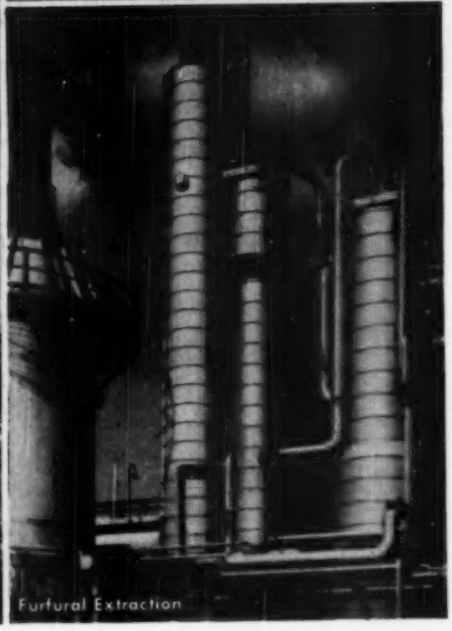
Proof of



Atmospheric-Vacuum Crude Distillation

M.E.K. Dewaxing

Propane Deasphalting with Modifier



Furfural Extraction

Satisfaction

This crude distillation and lube oil finishing program plus gasoline and water treating facilities, in Paulsboro, N. J., recently completed by Badger for Socony-Vacuum Oil Company, Inc., represents a continuation of our services to the same client over a period of 23 years.

Badger regards repeat orders as fundamental indication of client satisfaction.

E. B. BADGER & SONS CO · Est. 1841

A SUBSIDIARY OF STONE & WEBSTER, INC.

BOSTON 14 · NEW YORK

PARIS · LONDON

Process Engineers and Constructors for the Petroleum, Chemical and Petro-Chemical Industries

High Pressure

MEETS ITS MATCH

Made from Alloy Steel—from the furnaces of Republic, world's leading alloy steel producer.

No matter how high the operating pressure, Republic Upson Alloy Steel Studs stay "on stream" without flinching. These tough, heavy-duty studs are built to hold fast under extreme operating conditions . . . built for complete dependability . . . built to stay on the job and keep maintenance costs at all-time lows.

They also provide positive resistance to corrosion and to elevated temperatures. Replacements? . . . You can be *sure* if you use Republic Upson Alloy Steel Studs. New equipment? . . . Why not *specify* them and forestall high pressure worries?

REPUBLIC STEEL CORPORATION
BOLT AND NUT DIVISION • CLEVELAND 13, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

REPUBLIC *Known for Quality* **ALLOY STEEL STUDS**

Other Republic Products Include Machine, Tank and Carriage Bolts—Lag Screws, Cap Screws and Rivets

Here's Why KAYLO LAMINATED PANELS *Assure* FIRE-SAFE WALLS

IN ONE OPERATION, 32 square feet of fire-safe wall goes into place. Kaylo Laminated Panels, with cement-asbestos facing, are only two inches thick and lightweight, yet they have better insulating value than 16" of concrete. Panels can be sawed, nailed or bored, with standard tools.

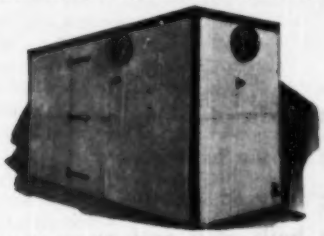
...Resist IMPACT... HEAT LOSS...ROT... WATER DAMAGE

The unique feature of Kaylo Laminated Panels is the Kaylo core, a remarkable new hydrous calcium silicate (not glass). It is the basic reason why Kaylo Laminated Panels offer so many important advantages to the oil industry.

This new type of inorganic core material has a high percentage of microscopic voids, giving it exceptional resistance to heat passage. The incombustible Kaylo core is securely bonded to facings of cement-asbestos or metal with a waterproof adhesive. Installed with proper joint systems, the Kaylo Laminated Panels meet A.S.T.M. one-hour fire standards.

Sandwich construction plus the strong Kaylo core gives Kaylo Laminated Panels exceedingly high strength, dimensional stability and resistance to impact. The inorganic Kaylo core is rot-proof, vermin-proof and insoluble in water.

Kaylo Laminated Panels provide better curtain-walls or interior partitions with reduced building load and easier erection for nearly every type of building. Investigate now.



In this typical installation, Kaylo Laminated Panels (with cement-asbestos facing) are used on a valve house.

SEE OUR CATALOG IN

A VARIETY OF FACINGS ARE AVAILABLE on Kaylo Laminated Panels, including: cement-asbestos, wood veneer, and metals.

KAYLO®

LAMINATED PANELS

OWENS-ILLINOIS GLASS COMPANY

KAYLO DIVISION • TOLEDO 1, OHIO

SALES OFFICES:

Atlanta · Boston · Buffalo · Chicago · Cincinnati · Houston · Minneapolis · New York
Oklahoma City · Philadelphia · Pittsburgh · St. Louis · Toledo · Washington

Send Coupon for Literature!

OWENS-ILLINOIS GLASS COMPANY
Kaylo Division, Dept. N-90, Toledo 1, Ohio

Gentlemen: Please send me literature on Kaylo Laminated Panels

NAME.....

FIRM.....

ADDRESS.....

CITY.....STATE.....

What WE build we build good

This is not a part of a ship or marine vessel, nor the nose of a huge torpedo. It is a section of a 55 foot diameter oil refining unit. It is being built in our plant where a large variety of similar equipment is built each year as regular products of this plant. Note the true shape and the accurate fits. Because of our vast facilities and long experience no job is too large and "what we build we build good."

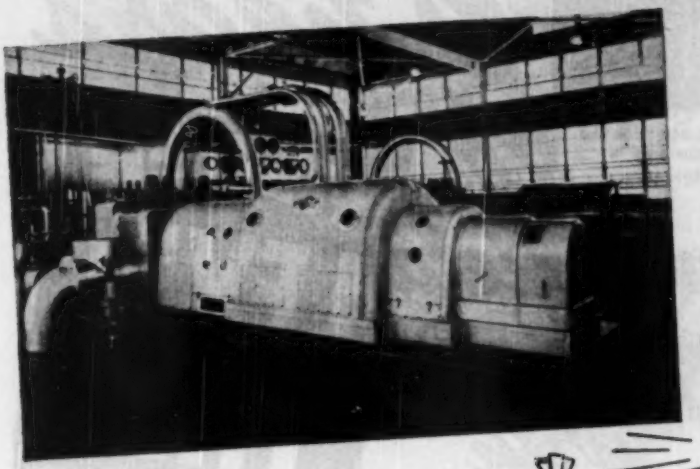
Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE SINCE 1916 CHESTER, PENNA.

25 BROADWAY • NEW YORK CITY

HANDLING TWO JOBS AT ONCE...



and saving money on both!

Two 1500 KW Worthington turbine-generators, installed in the Eunice, N. M. plant of the El Paso Natural Gas Company. These are non-condensing extraction turbines designed to operate on initial steam conditions of 575# — 575° FIT exhausting at 5#G back pressure.

Worthington Turbine-Generators Selected By Natural Gas Firm For Both Power and Product-Conditioning

Pumping natural gas from southeastern New Mexico and the Texas Panhandle to points in California and Arizona, the El Paso Natural Gas Company uses Worthington Turbine-Generators for double duty. Besides furnishing electricity for the company's plant in Eunice, N. M., the turbines automatically extract steam at 125#G for heating Amine solution, which is mixed with the gas to remove impurities.

In every branch of industry, users are getting daily proof of the outstanding flexibility of Worthington Turbine-Generator Sets — not only as sources of more dependable, more economical electric power, but as cost-cutting suppliers of processing steam for many important allied purposes.

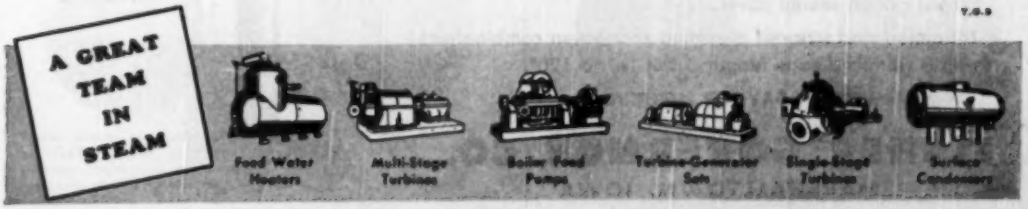
WORTHINGTON TAKES ALL THE RESPONSIBILITY

Worthington builds Turbine-Generator Sets in sizes up to 10,000 kw, and in all types. Each is designed to make steam do more work, and each is backed by Worthington's undivided responsibility for the complete unit's design, assembly and performance. For expert aid in selecting the *right* size and type for your own requirements . . and further proof that *there's more worth in Worthington* . . call our nearest District Office. Or write to *Worthington Pump and Machinery Corporation, Steam Turbine Division, Wellsville, N. Y.*

WORTHINGTON

STEAM TURBINES

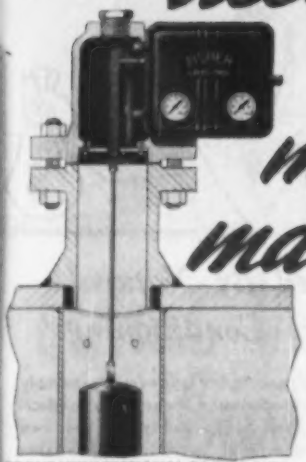
V-2-9



TYPE 2405-249
EXTERNAL MOUNTING
LEVEL-TROL

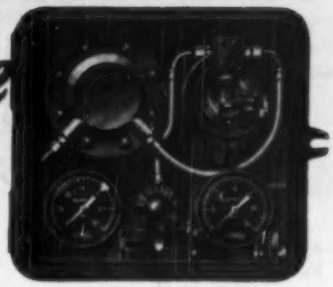
6 years of proven field acceptance with minimum maintenance

FISHER LEVEL-TROL



FRONT VIEW SECTIONAL OF TYPE 2405-249P TOP MOUNTING LEVEL-TROL

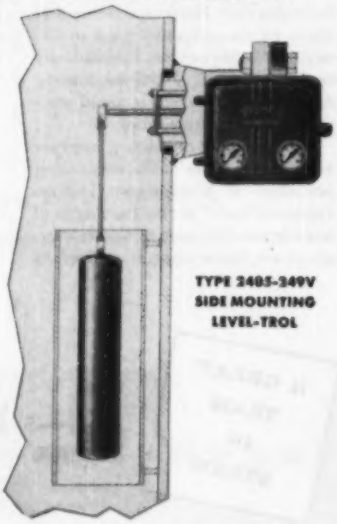
Fisher Level-Trol is designed for accurate and precise control of all liquids at all specific gravities and temperatures. Available in internal or external mounting constructions for indicating or controlling liquid level.



TYPE 2405 LEVEL-TROL PILOT

Features

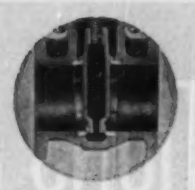
- Pilot is entirely pneumatic in operation. No intervening links or mechanical joints.
- One control knob with calibrated scale for proportional band and specific gravity adjustment.
- Torque tube can be exchanged or replaced without dismantling entire level controller or breaking into pressure piping.
- High-tensile iron, pressure-tight weatherproof case with hinged gasket sealed cover.
- 8 flanged and screwed mounting connection combinations with 8 standard cage lengths from 14" to 120".



TYPE 2405-249V
SIDE MOUNTING
LEVEL-TROL

WRITE TODAY FOR BULLETIN F2

FISHER GOVERNOR CO.
MARSHALLTOWN, IOWA



Straight-Flow Port Design reduces fluid turbulence to a practical minimum.

Seat Rings of end-seated type are screwed into the body.

Sure-Grip Malleable Handwheel for non-skid gripping even with heavy gloves.

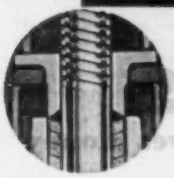
WALWORTH

iron body gate valves

with screwed or flanged ends

For complete information on these new Walworth Iron Body Valves, see your local Walworth distributor, or write for bulletin 106.

... 8 Outstanding Features



Brass Liner on Glands assures greater resistance to corrosion and scoring.

WALWORTH

valves and fittings

60 EAST 42nd STREET NEW YORK 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

T-head Disc-to-Stem connection on OS&Y types provides stronger connection, prevents loosening of disc by corrosion.

Bronze Back-Seat Bushings in bonnets of OS&Y valves.

Solid Web Type Disc in OS&Y valves for greater strength and longer service.

Hinged Gland Eye-Bolts on OS&Y valves permit faster, easier repacking under full pressure.

2 GREAT PIPE INSULATIONS

Unibestos No. 750 - to 750° F.
Unibestos No. 1200 - to 1200° F.

Available in Cylinders or Half-rounds

UNIBESTOS®

. . . single-layer application saves money

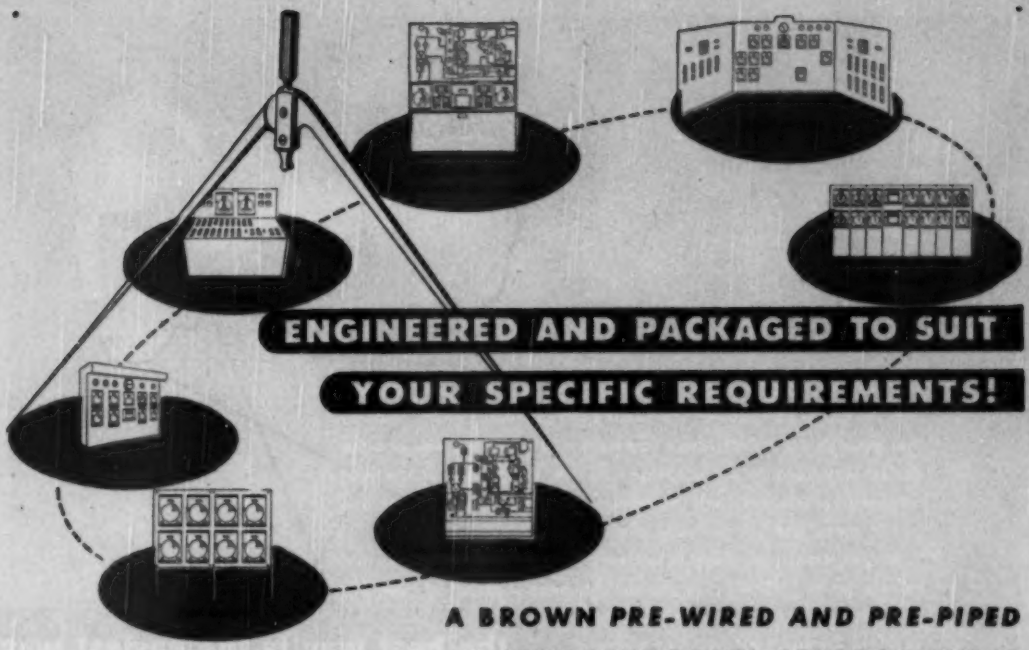
When you can insulate a pipe efficiently with only one layer of covering, you save money. The range of thicknesses in which Unibestos Pipe Insulations are made permits the economies of single-layer application. Also a distinct saving in warehousing is made possible because fewer sizes of insulation are required in stock for maintenance work. But range of insulation thicknesses for single-layer application is only one of the many features of these 2 great pipe insulations—UNIBESTOS No. 750 and No. 1200. Write today for catalog giving complete information.*

UNARCO

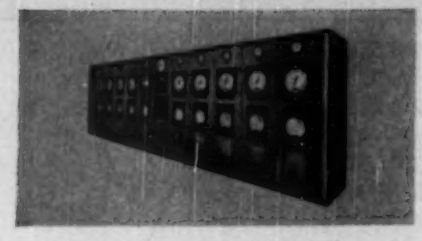
UNION ASBESTOS & RUBBER COMPANY

1823 SOUTH 54th AVENUE • CICERO 50, ILLINOIS

**New 8-page catalog (No. 48-1023) "UNARCO Insulations • Asbestos Packings • Gaskets • Textiles"*



ENGINEERED AND PACKAGED TO SUIT YOUR SPECIFIC REQUIREMENTS!



This unit illustrates one of the variety of types of Packaged Panels now available to industry . . . engineered and assembled by a corps of panel design specialists to fit the specifications of the simple as well as the complex processes.

A BROWN *PRE-WIRED AND PRE-PIPED INSTRUMENT PANEL* AFFORDS THESE OUTSTANDING ADVANTAGES . . .

A Relieves you of costly details involved in obtaining panel materials, accessories and fittings . . . and preparing wiring and piping diagrams and layouts.

B Simplifies installation . . . you receive a complete unit, fitted to your process, requiring only a minimum of connections.

C Simplifies maintenance . . . orderly arrangement of instruments and components permits easy access for checking and service.

D Adds new efficiency and convenience to process operation by planned grouping of instruments for finger-tip control and at-a-glance checking.

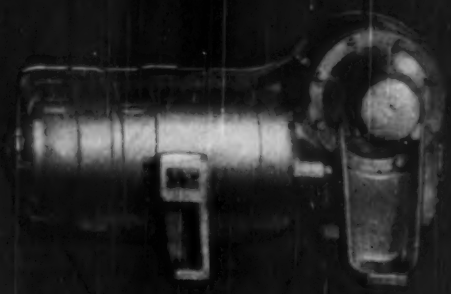
A PRE-WIRED and pre-piped instrument panel can be designed and produced to your specifications in any one of the seven basic types illustrated!

Your local Honeywell engineer is qualified to discuss the details of your process requirements and to recommend the type of Packaged Panel best suited to your operations. Call him in today . . . he is as near as your phone!

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4498 Wayne Ave., Philadelphia 44, Pa. Offices in more than 80 principal cities of the United States, Canada and throughout the world.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS



The best way to power any application is to secure, in one compact unit, the RIGHT horsepower, the RIGHT shaft speed, the RIGHT features that you can use RIGHT where you want it. It's the best way and the easiest way because you purchase one unit, handle one unit in your receiving, production, and maintenance departments . . . set one unit in place and you're ready to go.

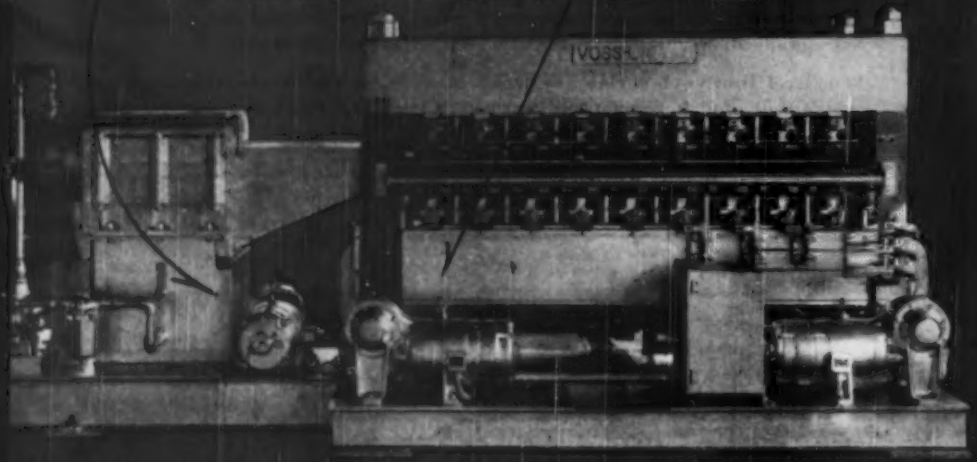
Master Motors, available in thousands and thousands of types and ratings (up to 150 HP) give you an enormous selection of integrally built power drives from which you can easily select the combination of features that's just right for each job.

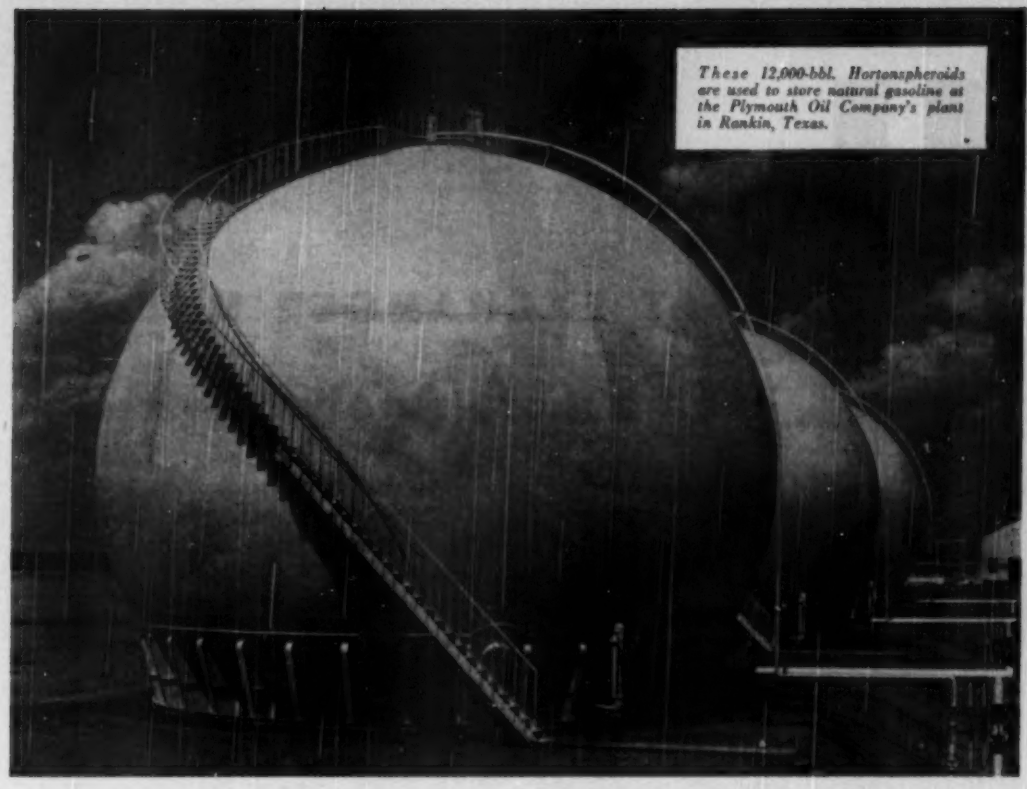
the best way is the easiest way

Open, enclosed, splash proof, fan-cooled, explosion proof . . . horizontal or vertical . . . for all phases, voltages and frequencies . . . in single speed, multi-speed and variable speed types . . . with or without flanges or other special features . . . with 5 types of gear reduction up to 432 to 1 ratio . . . with electric brakes . . . with mechanical variable speed units . . . and for every type of mounting . . . Master has them all and so can be completely impartial in helping you select the one best motor drive for YOU.

Select the RIGHT power drive from Master's broad line and you can increase the saleability of your motor driven products . . . improve the economy and productivity of your plant equipment.

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO





These 12,000-bbl. Hortonspheroids are used to store natural gasoline at the Plymouth Oil Company's plant in Rankin, Texas.

The *where* and *why* of storing Natural Gasoline

Where (in what type tank) should you store natural gasoline? If you want . . . to protect the volatility and octane rating . . . take advantage of seasonal price variations . . . keep the fire hazard to a minimum —then the Hortonspheroid is the container for you.

Why does the Hortonspheroid give you these benefits? It protects the volatility and octane rating of natural gasoline because it is designed specifically to prevent the excessive evaporation losses that occur when the volatile liquid is stored in conventional tanks. The Hortonspheroid can withstand the maximum pressure variations caused by daily temperature change—and so does not vent the light fractions under normal operating conditions. These light fractions are important for they give natural gasoline most of its value as an ingredient of blended motor fuel.

Here's how to take advantage of seasonal price variations. Purchase or produce your natural gasoline in the spring when the market price is low. Then store it in the Hortonspheroid until the fall when the demand (and price) is greater.

Since the Hortonspheroid does not vent under normal conditions, the fire hazard is reduced.

Plain Hortonspheroids (above) are built to capacities from 2,000 to 40,000-bbls. while noded Hortonspheroids (right) are built in capacities up to 120,000-bbls. Write our nearest office for Bulletin E for details.

Noded Hortonspheroid

CHICAGO BRIDGE & IRON COMPANY

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PENNSYLVANIA

Atlanta 3	2146 Healey Building	Detroit 26	1520 Lafayette Building	Philadelphia 3	1608—1700 Walnut Street Building
Birmingham 1	1548 North Fiftieth Street	Havana	402 Abreu Building	Salt Lake City 4	531 West 17th South Street
Boston 10	1030—201 Devonshire Street	Houston 2	2126 National Standard Building	San Francisco 4	1551—200 Bush Street
Chicago 4	2463 McCormick Building	Los Angeles 17	1534 General Petroleum Building	Seattle 1	1331 Henry Building
Cleveland 15	2234 Guildhall Building	New York 6	3302—165 Broadway Building	Tulsa 3	1626 Hunt Building

REPRESENTATIVES AND LICENSEES

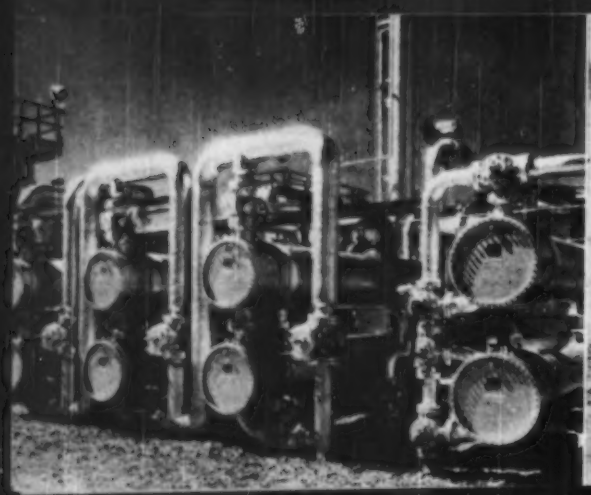
Ateliers et Chantiers de la Seine Maritime, Paris, France
Compagnia Tecnia Industrie Petroli, Rome, Italy
Constructions Metalliques de Provence, Arles-sur-Rhone, France
Chicago Bridge & Iron Company, Ltd., Apartado 1348, Caracas, Venezuela
Horton Steel Works, Limited, Fort Erie, Ontario, Canada
Motherwell Bridge & Engineering Company, Limited, Motherwell, Scotland
Whessoe, Limited, Darlington, England
Comprima N. V., Amsterdam—O, Netherlands
Sociedade Chibridge de Construcoes Ltda., Rio de Janeiro, Brazil

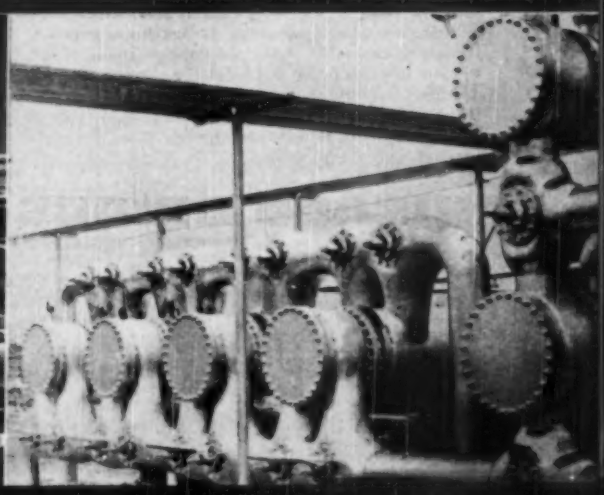
How HEAT EXCHANGER UNITS can be more safely serviced

Heat exchanger batteries are usually in continuous operation with piping arranged so that individual units may be taken out of service for maintenance without interrupting flow through the other units. The success of this operation is dependent on reliable and effective switching valves. If equipped with conventional valves which are vulnerable to leakage or failure, unit maintenance becomes difficult and hazardous or the entire battery may have to be shut down. But, if equipped with Nordstrom valves, individual units can be serviced readily because there's *no leakage, no hazard, no valve failure.* Uninterrupted plant operation, with Nordstroms, can easily save far more than the cost of the valves.

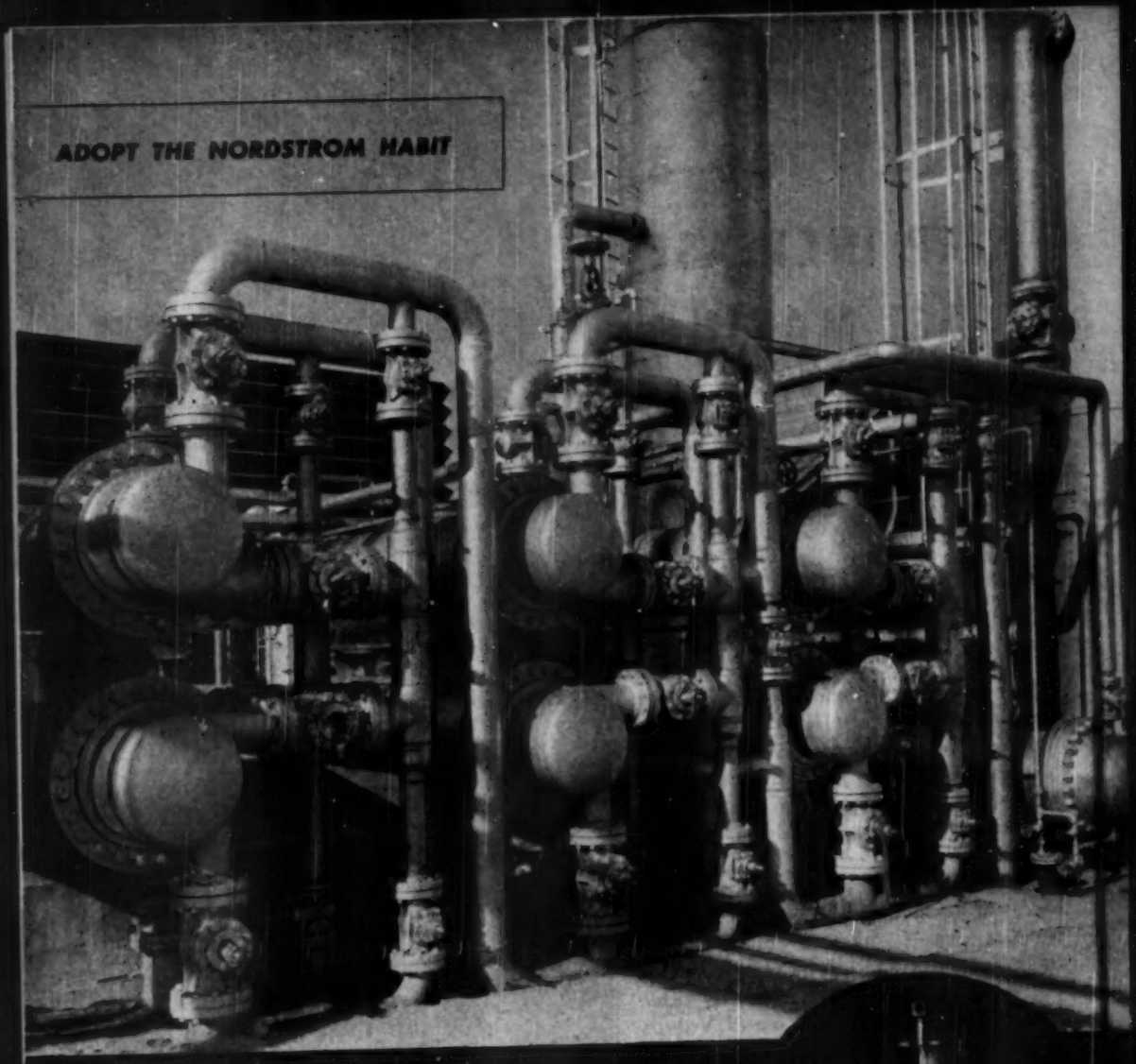
Adopt this habit...

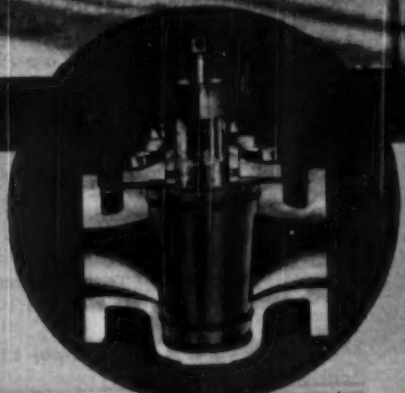
Each time a troublesome heat exchanger valve demands replacement—change to a Nordstrom. Eventually the entire battery will be Nordstrom-equipped. The cost? No more than ordinary valves when you figure the improved service and greatly increased valve life.





ADOPT THE NORDSTROM HABIT





Nordstrom

LUBRICATED Valves

NOW AUTOMATICALLY LUBRICATED WITH Hypermatic

PATENTS ADAPTED FOR

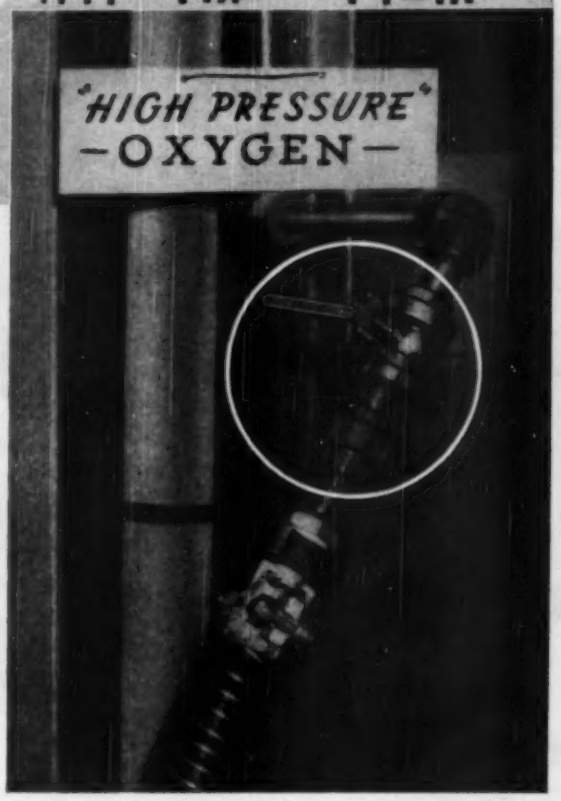
TRADE MARK

ROCKWELL MANUFACTURING CO.

400 N. Lexington Ave., Pittsburgh 8, Pa. • Offices in all Principal Cities

Rockwell Mfg. Co., International Division, Empire State Building, New York 1

ROCKWOOD BALL VALVES HELP INCREASE STEEL MAKING CAPACITY



No place for leaky valves on this high pressure oxygen line where careful control of the flow of oxygen to the open hearth furnaces is necessary at all times.

The Rockwood Ball Valve was selected by this large steel corporation primarily for its quick turn on and off action and leak proof service. These outstanding features of the Rockwood Valve enables furnace operator to properly control the oxygen which is used for the melting process that helps increase furnace capacity.

The seven features on the right are the secret of Rockwood Ball Valves' dependable service — why you can count on them to stay on the job indefinitely without leaks or maintenance. Industry after industry has found Rockwood Valves reliable — in oil refineries, food, paper, chemical and rubber plants, etc.

You can have Rockwood Valves in bronze in all pipe sizes from ½" to 2" for 300 p.s.i. working pressure.

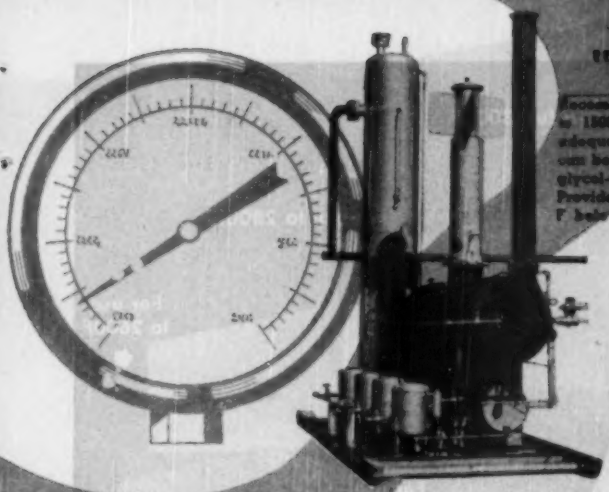
Additional information and uses will be promptly supplied — write for Bulletin V-4.

Distributors in all principal cities.

1. **Full round open area - no turbulence in fluid stream.**
2. **Leak proof after continued use.**
3. **New floating ball - resists pitting, scratching & abrasion.**
4. **No exposed seating surface in open or closed position.**
5. **Easy to open or close under full pressure.**
6. **Installed in any position.**
7. **Quarter turn (90°)opening and closing valve.**

ROCKWOOD SPRINKLER CO

102 HARLOW STREET WORCESTER 5, MASS



"WET" METHOD

Recommended for operating pressures up to 1500 psi, where partial dehydration is adequate . . . or where gas temperature can be controlled. Concentrated triethylene glycol-water solutions serve as desiccant. Provide a dew-point depression 60° to 75° F below gas temperature! Low in cost.

LOW or HIGH PRESSURE *Dehydration*

"DRY" METHOD

More effective, using solid granular absorbent, capable of reduction to less than one pound of water vapor per million feet of gas. Pressures up to 2000 psi and above are handled with great efficiency.

Up go gathering and transmission line pressures in meeting today's vastly greater demand for natural gas. But increased pressures mean increased troubles from hydrate formation. UNLESS there's a BS&B Dehydrator on the job!

BS&B Engineers have fought hydrates for years . . . and they are now well ahead of the problem. Two basic types of dehydrating systems are now ready to serve you. Each has advantages in overcoming certain phases of the problem. Each eliminates costly, troublesome, time-wasting, labor-consuming freeze-ups. And they're so efficient that it is cheaper to dehydrate than to heat!

Remember, once water is removed, hydrates are gone for good, never to plague you again further along in processing.

Up-to-the-minute reports are available to you concerning BS&B's continuing progress in dehydration. For all the facts as they concern your operation, call your nearest BS&B Sales Engineer today . . . or fill in coupon below.

Black, Sivalls & Bryson, Inc.

KANSAS CITY • TULSA • OKLAHOMA CITY

Cable Address: BLACKSIV, New York

BS&B

GAS DEHYDRATORS

BLACK, SIVALLS & BRYSON, INC., Section 2-23-18

7500 E. 12th St. Kansas City 3, Mo

I want more information about BS&B's progress in Dehydration. I am interested in ☐ "Wet" process ☐ "Dry" process at approximately _____ psi pressure.

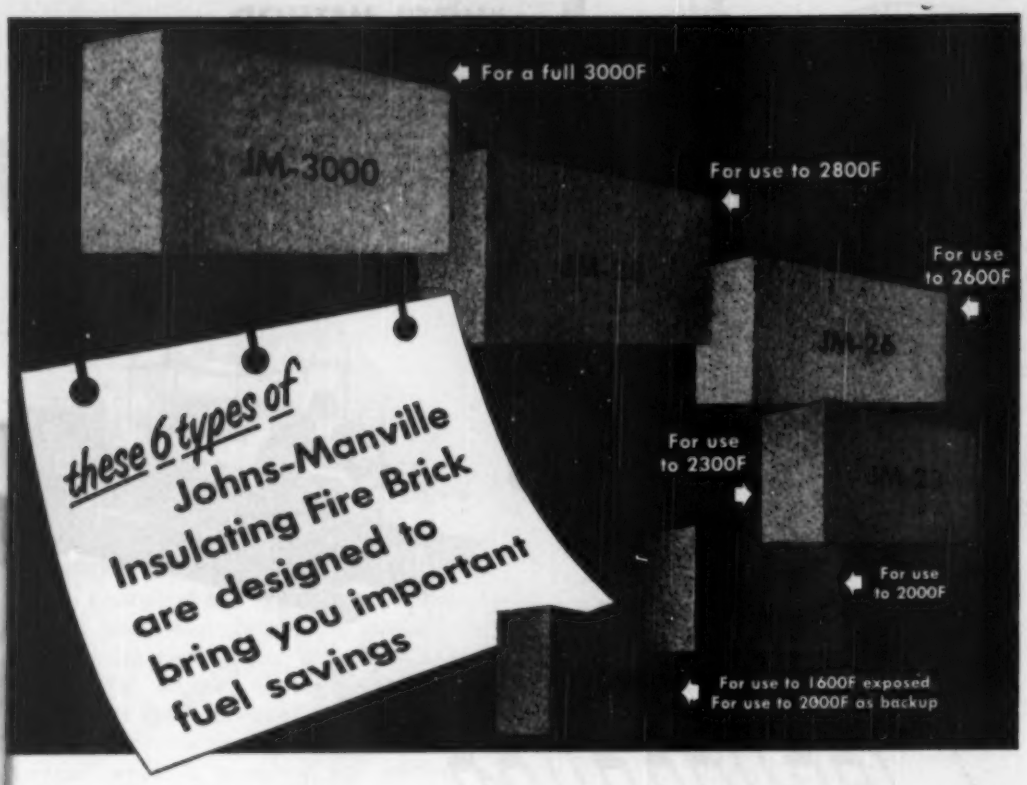
NAME _____

TITLE _____

FIRM _____

STREET _____

CITY _____ STATE _____



You can make important savings in fuel by taking advantage of the quick heating characteristics of J-M Insulating Fire Brick. These light-weight brick permit a quicker rise to proper operating temperature in the furnace because of their low heat storage capacity, and low thermal conductivity. Where furnaces are being intermittently operated these are two especially important characteristics.

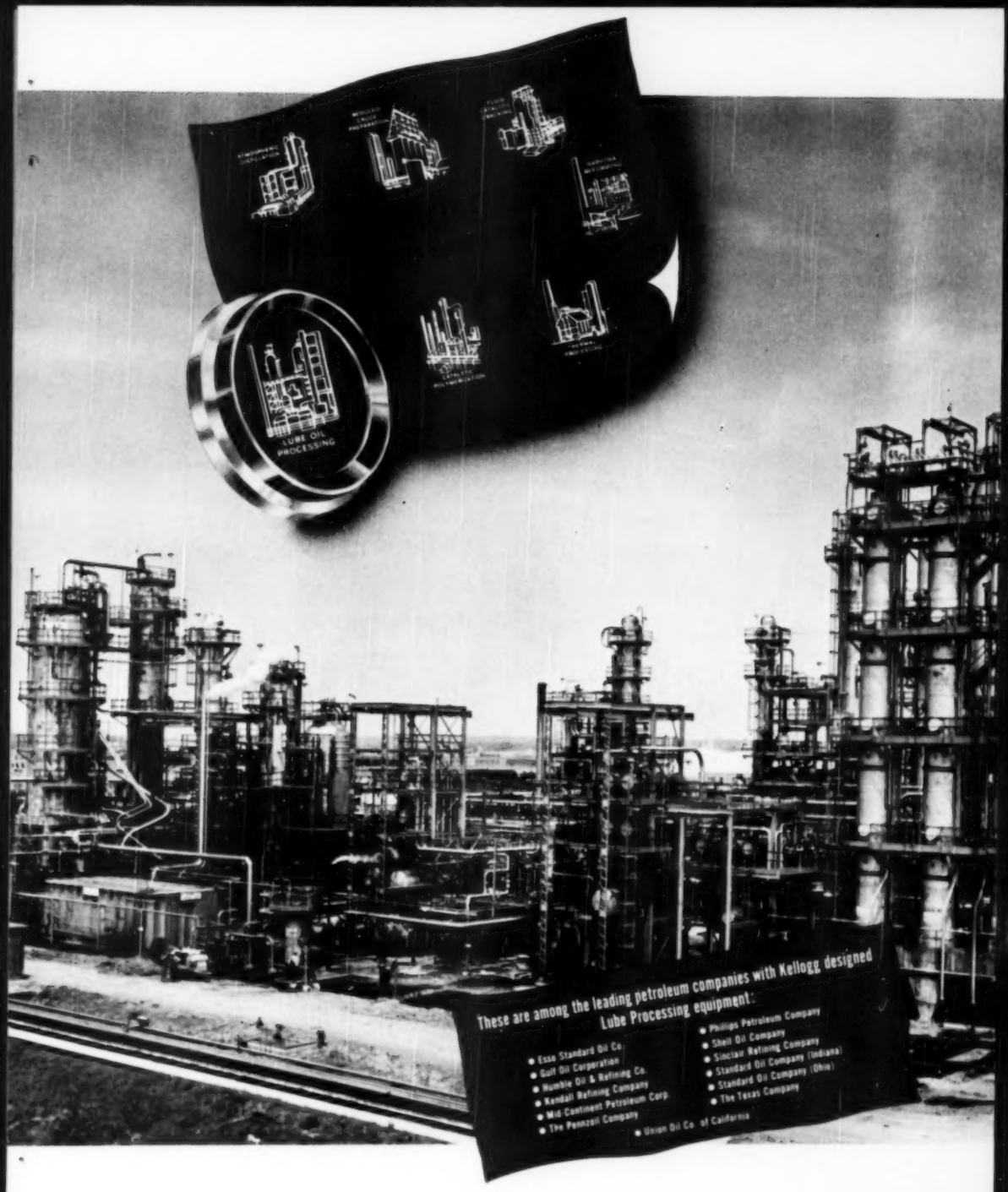
These same insulating materials can also be obtained in large size units called Johns-Manville Insulating *Fireblok*. This product has many advantages over the smaller size fire brick for certain types of jobs . . . from both a construction and stability standpoint. The Fireblok units can be quickly applied because they are easy to cut and fit. Fireblok insulations provide additional heat savings because they reduce the number of joints, and require less mortar for bonding.

It will pay you to let a Johns-Manville insulation engineer explain the many ways in which you can save by using these insulations in your furnaces. Just write for further information to Johns-Manville, Box 290, New York 16, N. Y.

	JM-1620	JM-23	JM-23	JM-26	JM-28	JM-3000
Densities, lb per cu ft	29	35	42	48	58	63-67
Transverse Strengths, psi	60	80	120	125	120	200
Cold Crushing Strengths, psi	70	115	170	190	190	400
Linear Shrinkage†, percent	0.0 at 2000 F	0.0 at 2000 F	0.3 at 2300 F	1.0 at 2600 F	4.0 at 2800 F	0.8 at 3000 F
Reversible Thermal Expansion, percent	0.3—0.6 at 2000 F †	0.3—0.6 at 2000 F	0.3—0.6 at 2,000 F	0.3—0.6 at 2000 F	0.3—0.6 at 2000 F	0.3—0.6 at 2000 F
Conductivity* at Mean Temperatures						
500 F	0.77	0.97	1.31	1.92	2.00	3.10
1000 F	1.02	1.22	1.91	2.22	2.50	3.20
1500 F	1.27	1.47	2.31	2.52	3.00	3.33
2000 F	—	1.72	2.70	2.82	3.50	3.60
Recommended Service						
Back up	2000 F	2100 F	2300 F	2600 F	2800 F	3000 F
Exposed	1600 F	2000 F	2300 F	2600 F	2800 F	3000 F

†24-hr. simulative service panel test for JM-3000; 24-hr. soaking period for other brick. *Conductivity is expressed in Btu in. per sq ft per F per hour at the designated mean temperatures. Note: Above tests are in accordance with A.S.T.M. tentative standards.

Johns-Manville *first in* **INSULATIONS**


LUBE OIL
PROCESSING
These are among the leading petroleum companies with Kellogg designed
Lube Processing equipment:
• Esso Standard Oil Co.
• Gulf Oil Corporation
• Humble Oil & Refining Co.
• Kendall Refining Company
• Mid Continent Petroleum Corp.
• The Pennzoil Company
• Phillips Petroleum Company
• Shell Oil Company
• Sinclair Refining Company
• Standard Oil Company (Indiana)
• Standard Oil Company (Ohio)
• The Texas Company
• Union Oil Co. of California

Kellogg-designed lube facilities have a total charge capacity of more than 100,000 barrels per day!

Yes! More than 35 million barrels of lube stocks are charged to Kellogg units each year!

From Pennsylvania's select crude to the Middle East's highly asphaltic stock, Kellogg's lubricating oil units are used to process virtually every type of feed. From single-unit propane deasphalters to entire lube plants, including everything from vacuum towers to barrel-house facilities, Kellogg's experience is complete.

The pictured plant illustrates the unusual conversion of a surplus wartime alkylation-isomerization unit into a modern five-step plant for the production of high quality lubes. Today this plant is considered among the most modern and efficient in the world.

Kellogg offers refiners unduplicated experience in designing lube oil facilities, extending back over more than two decades, and now including the broadest choice of lube oil processes.

ENGINEERING HAS MARKED THE ADVANCES IN LUBE OIL REFINING!

Both lube oil specifications and lube refining economics have been subjected to extremely close scrutiny in recent years. Research by oil companies, pinpointing specifically desired product qualities, has set standards that design engineers have worked to match through improved equipment. Kellogg engineers have contributed much to this progress, bringing forth in a comparatively short space of time the Tower method of deasphalting, the water rejection principle for counter-current solvent extraction, propane fractionation, wax de-oiling and improvement in vacuum fractionating efficiency which enables refiners to make extremely narrow cuts at low cost.

IT TAKES ALL SEVEN TO PRODUCE GREATER EARNING POWER . . .

1 THE DEVELOPMENT "TOOLS"
—laboratories, pilot plants and recognized specialists to prove and improve processing and equipment ideas.

3 SPECIALISTS IN EVERY PHASE
of design engineering due to the completeness of Kellogg's engineering staff.

4 SPECIALIZED BUYERS
backed by the cumulative buying power of the largest company in the business.

5 COMPLETE FABRICATING FACILITIES
to make schedule deadlines and to develop workable "firsts" in refinery equipment.

6 CONSTRUCTION KNOW-HOW
acquired in completing hundreds of major jobs, plus an ample supply of the proper tools, and the constant development of new money-and-time-saving methods on the construction lot.

7 PRACTICAL OPERATING COUNSEL
on all design and construction, achieved through practical operating men working as an integral part of the company.

2. PROCESS ENGINEERING
by three distinct groups of specialists—the overall sequence planners, the specific process designers and the development engineers. The work of the first two groups is increasingly apparent in the new plants that continue to rise on the industrial landscape. The development engineer makes "headlines" with new processes, too, and Kellogg's development people have had their share. But many of their contributions to more economical processing go unheralded, although they are woven in to each new project —a new method of stripping here, a new method of introducing catalyst there, a double-function tower or furnace in another facility.
Hidden as details of large over-all plans, these daily advances in refining efficiency are reflected over the years in improved earnings for refiners.

. . . AND ONLY KELLOGG HAS ALL SEVEN!

The M. W. Kellogg Company, (a subsidiary of Pullman Incorporated), New York, Jersey City, Los Angeles, Tulsa, Houston, Toronto, London, Paris

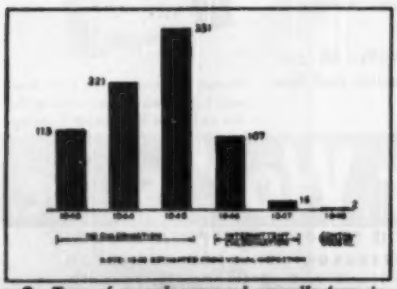
CHLORINATION BY WALLACE & TIERNAN

CONTROLS MARINE FOULING AT GENERATING STATION

LOOK AT THESE RESULTS

1. Before chlorination — mussels cover wall to depth of 3".

2. After chlorination — note bare wall.



3. Tons of mussels removed annually from intake tunnel of generating station.

It all began when a New England generating station sent down a diver for a routine inspection of the large, concrete, circulating-water, intake tunnel located approximately 13 feet below the harbor's surface. The diver discovered this intake was lined with unusually heavy growths of common mussel (Mytilus), sea moss (Tubularia), and sea anemone (Metridia).

These were expensive visitors. First, mussel accumulation created poor vacuum as the mussels lodged in condenser tubes and aggravated slime and silt formation. Then, as the mass increased in quantity, it became necessary to clean the intake tunnel every year to remove up to a maximum of 331 tons of mussels — a time consuming process that cost thousands of dollars in labor and equipment outage.

To combat these conditions a long and thorough study was made of marine fouling. As a result it was decided to use intermittent chlorination applied by Wallace & Tiernan Chlorinators. First to fall under this attack were the sea moss and the sea anemone. The tougher mussels however, still remained as numerous as ever.

In an all out effort to get rid of these trouble makers, continuous chlorination at heavier residuals was started. This treatment turned the trick and the mussels were reduced to such a low level that yearly cleaning has not been required.

These results saved the New England company thousands of dollars annually by eliminating intake tunnel cleaning, reducing condenser outages, and producing a higher vacuum with a resultant saving in fuel.

Perhaps your problem is one of slime or fouling due to some other marine organism. In any event, if biological fouling is costing you money through lowered cooling water efficiency it's a safe bet that chlorination can help.

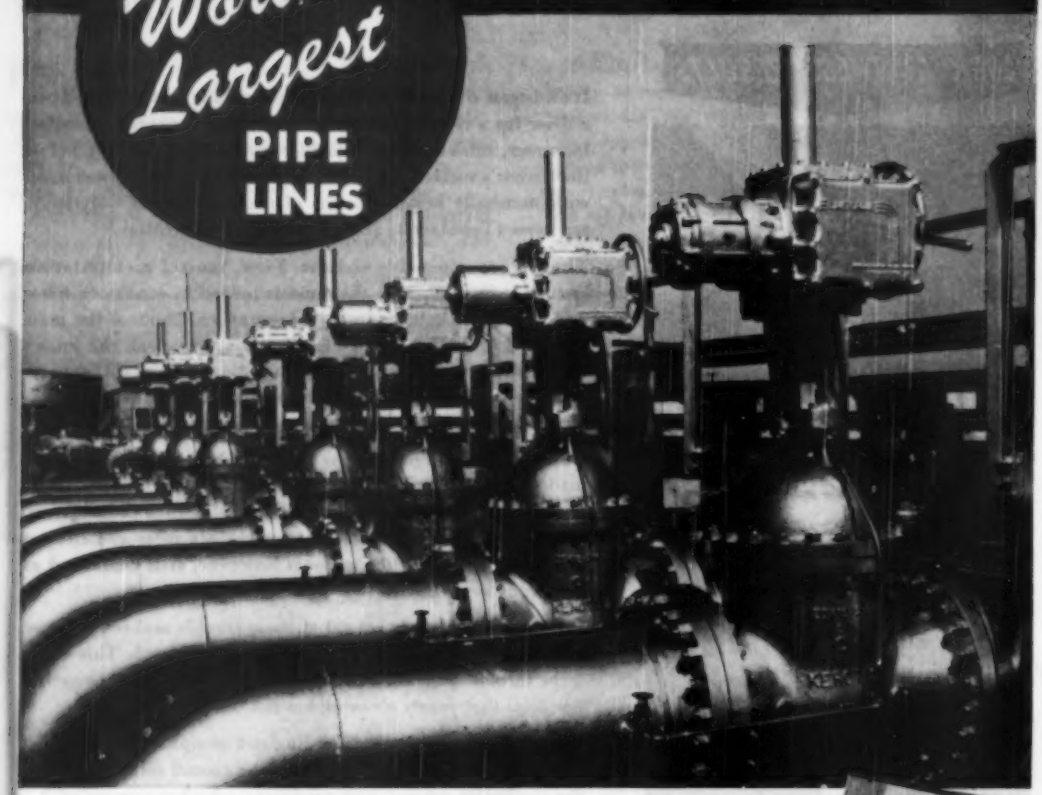
See your nearest Wallace & Tiernan Representative now for all the details.

CD-34

WALLACE & TIERNAN
PRODUCTS, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
Belleville 9, New Jersey • Represented in Principal Cities

ON THE *World's Largest* PIPE LINES

LIMITORQUE VALVE CONTROLS



Hundreds upon hundreds of LimiTorque Valve Operators are used on Pipe Lines and in Refineries throughout the world, because they operate (at the mere "push of a button") . . . under the most severe conditions of Heat or Cold, Rain, Snow, Dust, Dirt or Fumes . . . night and day . . . year-in and year-out—LimiTorque *saves* time, labor and money by *eliminating manual operation* of valves at distant locations. It opens and closes valves at the *exact* speed required, and is *absolutely dependable and safe*. Also, as the name implies, LimiTorque *limits the torque* applied to valve operating parts, and thus *prevents damage* to stems, discs and seats, etc.

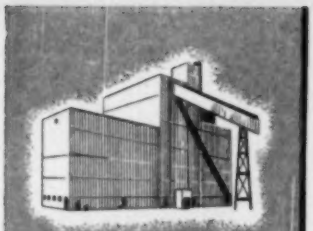
LimiTorque utilizes any available power source for operation: electricity, oil, gas, water or air. You take no chances with LimiTorque, because it has been tested and time tried under all conditions over a long period of years.

Please be sure to use your Business Letterhead when writing for this valuable illustrated Catalog.

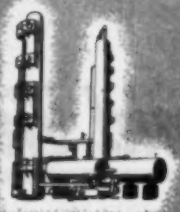
Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON
IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

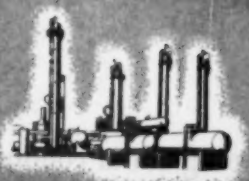
Industrial Gears and Speed Reducers
LimiTorque Valve Controls



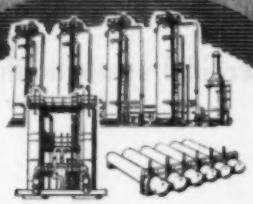
POWER DIVISION



CHEMICAL DIVISION

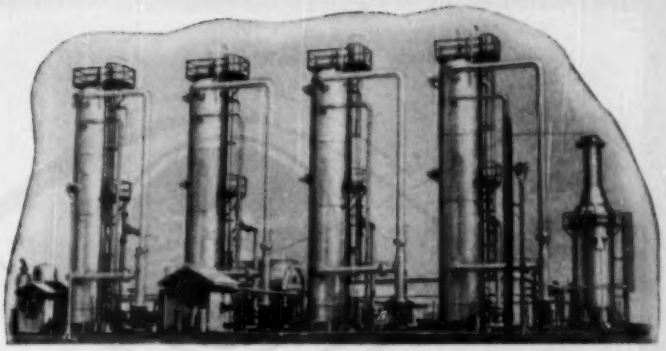


PETROLEUM DIVISION



NATURAL GAS DIVISION

DESIGN ENGINEERING and CONSTRUCTION for INDUSTRY



Natural Gas Dehydration Plant with a daily capacity of 300,000,000 SCF at 1000 psig, recently designed and engineered by Pritchard.

Industry Profits from Pritchard-Built Plants

For the most modern advancements in design, engineering and construction — to assure plants that produce higher profits and give trouble-free operation—consult J. F. Pritchard & Co. Pritchard-built plants are well known for their operational efficiency and quality of production.

J. F. Pritchard & Co. offers complete service from Analysis of Requirements through Economic Studies, Design, Processing, Engineering, Purchasing, Field Construction, Guarantees and full "On Stream" Operating Tests. Firm prices quoted on a "Turnkey" basis.

Take advantage of Pritchard's years of experience in the Gas Engineering field . . . Let J. F. Pritchard & Co. build profit-producing plants for you.

These Pritchard GAS ENGINEERING Services Are Available To You

- Compressor stations and additions
- Pressure maintenance units
- Desulphurization, amine type
- L.P.G. installations
- Conditioning and treating
- Cooling and heat transfer
- Removal of liquids and dust
- Gasoline plants

Write for *FREE* Bulletin

J.F. Pritchard & Co.

DESIGN • ENGINEERING • CONSTRUCTION

Dept. No. 33 908 Grand Ave., Kansas City 6, Mo.

District Offices:
CHICAGO • HOUSTON • NEW YORK • PITTSBURGH • TULSA • ST. LOUIS

Cyanamid Vision

New Aerocat® Catalyst Production Plant Spearheads Cyanamid Expansion

Cyanamid has taken another step forward in its program of continued expansion to help the petroleum industry meet the demand for greater production of higher octane fuels. At Michigan City, Indiana, work has begun on a new plant to produce microspheroidal synthetic fluid cracking catalyst.

The increased capacity of this plant is representative of the long-range vision that has maintained Cyanamid leadership since the inception of the fluid catalytic cracking process. And such vision is still at work every day at Cyanamid...ready to help you solve your catalyst problems.

spurs catalyst progress

Cyanamid 1st in Development... American Cyanamid research pioneered many of the "first facts" about fluid catalysts. That pioneering still goes on. *Today* it brings you a variety of highest quality fluid cracking catalysts, headed by AEROCAT MS Grades of microspheroidal synthetic fluid cracking catalyst. *Tomorrow* it will work toward the development of catalysts with even greater catalytic cracking efficiency.

Vision, Experience, Facilities, Service... is the combination that enables Cyanamid to produce better chemicals for the petroleum industry: AEROLUBE® Additives for motor oils... AERO* Specialty Catalysts for chemical processes... Gasoline Dyes and Drilling Mud Chemicals. To learn more about these products and how they can help you...

send today for samples and literature.

*Trade Mark

AMERICAN Cyanamid COMPANY

PETROLEUM CHEMICALS DEPARTMENT, DIV. B 10

30 Rockefeller Plaza, New York 20, N. Y.

Catalyst

When ∧ Performance counts... call on Cyanamid

3 IMPORTANT WAYS

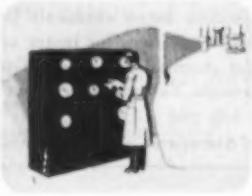
B&A "Custom-Made" Chemicals Help Leading Manufacturers Solve Production Problems

CASE #1—*Laboratory chemicals produced in commercial quantities for Pharmaceutical manufacturer!*

A pharmaceutical manufacturer needed a special chemical in compounding a new antiseptic preparation. Study proved B&A's purified Calcium Acetate, hitherto marketed only in laboratory size packages, fulfilled the requirements. B&A "know-how" and B&A productive facilities combined to give this manufacturer commercial quantities on time to meet pressing manufacturing schedules.

CASE #2—*Special form of basic chemical developed for Paint industry!*

A leading paint producer turned to B&A for Ammonium Oxalate of special quality and screen size urgently needed for a new type of paint formulation. Again, B&A met the problem, producing this new chemical form to exacting specifications, in the tonnages required.



CASE #3—*Exclusive formulation prepared from Textile manufacturer's secret specifications!*

Formula "X" was prepared in commercial quantities on short notice for a leading textile manufacturer . . . one of many customers who regularly entrust their private formulas to B&A. Naturally, both specifications and end uses are always held in strictest confidence.

WHAT IS YOUR PROBLEM?

Whether you need commercial quantities of a laboratory chemical, or an entirely new chemical "custom-made" for your specific use, it will be to your advantage to contact your nearest B&A office immediately. B&A has the men, methods, and materials to handle custom-made chemical assignments swiftly and surely.

BAKER & ADAMSON *Fine Chemicals*

GENERAL CHEMICAL DIVISION

ALLIED CHEMICAL & DYE CORPORATION

40 RECTOR STREET, NEW YORK 6, N. Y.

Offices: Albany • Atlanta • Baltimore* • Birmingham* • Boston • Bridgeport* • Buffalo* Charlotte* • Chicago* • Cleveland* • Denver* • Detroit* • Houston* • Jacksonville Los Angeles* • Minneapolis • New York* • Philadelphia* • Pittsburgh* • Providence* St. Louis* • San Francisco* • Seattle • Yakima (Wash.)
In Wisconsin: General Chemical Company, Inc., Milwaukee, Wis.

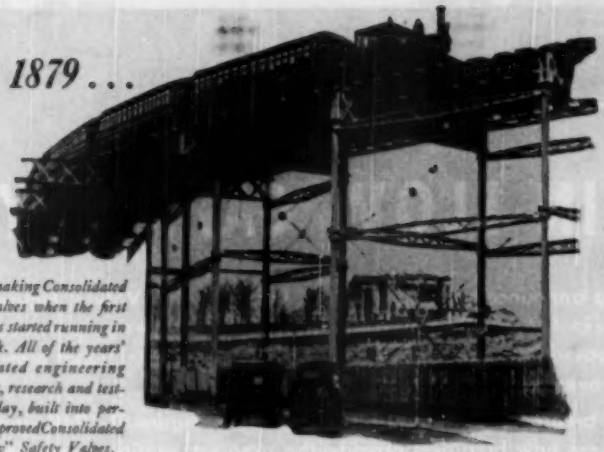
In Canada: The Nichols Chemical Company, Limited • Montreal* • Toronto* • Vancouver*

SETTING THE PACE IN CHEMICAL PURITY SINCE 1882

* Complete stocks are carried here.

REAGENTS B&A STANDARD OF PURITY FINE CHEMICALS

Since 1879 . . .



We were making Consolidated Safety Valves when the first "L" trains started running in New York. All of the years' accumulated engineering knowledge, research and testing is, today, built into performance-provedConsolidated "Maxiflow" Safety Valves.

Underwood & Underwood

There's over 70 years know-how built into CONSOLIDATED *Maxiflow* SAFETY VALVES

Maxiflow Safety Valves are new *in all that modern engineering can contribute.* But every feature of these valves has been proved by field experience over many years, and by long-time and severe testing methods.

In high pressure, high temperature installations, Maxiflow performance establishes a new standard in safety, efficiency and economy.

These Maxiflow design features mean important operating advantages:

Thermodisc Seat permits rapid equalization of temperature differentials. Thermal stresses are minimized, seat distortion cannot take place, permanent tightness is achieved.

Blowdown Control adjustable to a new, low minimum. The exclusive "micrometer" trim ring provides a simple and practical chatter-proof blowdown control, externally controlled and operable with valve under pressure.

Mechanical Through Bushing with precision machined surfaces that provide constant entrance conditions for steam flow. Eliminates leakage due to porous castings.

Retention of Popping Point is achieved by combining proper compensation with materials having low coefficients of expansion.

For complete description, plus capacity tables, write for the Consolidated Maxiflow Safety Valve Bulletin.

CONSOLIDATED *SAFETY* VALVES

A Product of

MANNING, MAXWELL & MOORE, INC.

BRIDGEPORT 2, CONNECTICUT

Makers of "Consolidated" Safety and Relief Valves, 'American' Industrial and 'Microsen' Electrical Instruments, 'Hancock' Valves, 'Ashcroft' Gauges. Builders of 'Shaw-Box' Cranes, 'Budgit' and 'Load Lifter' Hoists, and other lifting specialties

Now —

TOPS IN FLOW CAPACITY

We are pleased to announce our new series of Tank Breather Valves, Figure ST-6949, available in 4, 6, 8, 10 and 12 inch sizes. This new design provides tremendously increased flow capacities within the range of conventional pressure settings and overpressure tolerances.

This new series of breathers replaces our previous series, Figure ST-1949, and we believe that these new breathers provide the greatest venting capacities yet produced by anyone for the normally used, practical ranges. In addition, their manufacture is of superb quality, they are easily maintained, and their resistance to corrosion is unmatched.

These new S. & J. Breather Valves are certified for venting capacity when mounted and tested in exact conformance with A.P.I. Venting Standards, paragraphs 7.0 to 7.40 inclusive, by a qualified impartial certifying agency.

Give us the pressure ranges and overpressure tolerances under which you operate, together with a brief description of your storage, and we will gladly supply you with CERTIFIED flow capacity curves on a breather that will meet your conditions.

S&J

Shand and Jurs Co. 917 CARLETON STREET · BERKELEY · CALIFORNIA

NEW YORK 296 Madison Ave · CHICAGO 332 So. Michigan Ave · HOUSTON 810 M & M Bldg. · TULSA 310 Thompson Bldg. · LOS ANGELES 714 W. Olympic Blvd. · SEATTLE 3000 Western Ave

MONTREAL 360 Notre Dame St. · VANCOUVER 550 Beatty St. · DARLINGTON England

PAGE *Welding* ELECTRODES

Page-Allegheny *Stainless Steel*

AC or DC

ARC
—stable even at very low amperage

SLAG
—clean, easily removed

COATING
—resists cracking down to very short stubs

SELECTION
—complete line for welding every type of stainless

DELIVERY
—prompt from warehouses in Chicago, Denver, Houston, Philadelphia, San Francisco and the factory at Monessen, Pa.

ACCO

Monessen, Pa., Atlanta, Chicago, Denver, Detroit, Los Angeles, New York, Philadelphia, Portland, San Francisco, Bridgeport, Conn.

TRADE MARK

PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE

Get in touch with your PAGE Distributor

Puzzle for experts

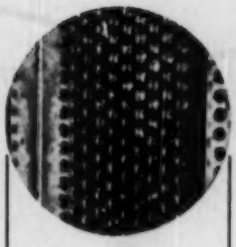
There is no need for "cutting and trying" on the job to make a prefabricated piping sub-assembly fit perfectly. Prefabricated miles away to exact dimensions and specifications these pieces of piping are links in piping systems which may carry steam up to 2500 p.s.i. and 1050°F.

Grinnell integrates the many factors in this complex, highly technical assignment in one organization of specialists. Major economies result from this single responsibility which includes interpretative engineering, metallurgical research, compliance with code requirements, manufacturing drawings and specifications, production schedules, purchase of materials, specialized facilities, skilled personnel, control of quality and rigid inspection.

You'll find it to your own best interests to draw upon Grinnell's century-long, specialized experience in power, process and industrial piping.

GRINNELL

Grinnell Company, Inc., Providence, R. I. Branches: Atlanta • Billings • Buffalo • Charlotte • Chicago • Cleveland • Cranston • Fresno • Kansas City • Houston • Long Beach Los Angeles • Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Pocatello • Sacramento • St. Louis • St. Paul • San Francisco • Seattle • Spokane



New heat exchanger for BAKELITE

—another example of Lummus' ability to meet Specialized Heat Transfer Requirements

When the Bakelite Division of the Union Carbide & Carbon Corporation planned for their new Marietta plant, they gave their heat exchanger problems to Lummus.

Working closely with Bakelite engineers, Lummus designed a total of 36 U tube bundles. The first stage of the plant consisted of 8 bundles of carbon steel tubes and 4 bundles of 4-6 chrome alloy tubes. The second stage consisted of 24 chrome alloy bundles. The tubes were 1½" O.D. for the first stage and 2" O.D. for the second stage with all tube sheets 1" thick stainless clad steel. But, to assure absolutely gastight tube to tube sheet joints, Bakelite specified that all tube ends were to be roller expanded and welded into the tube sheets.

In meeting this specification, Lummus engineers faced a double problem of warpage and distortion of the tube sheets: (first) from rolling the tubes and (second) from high welding heat.

To fabricate the bundles, Lummus built the special assembly of racks and welding jigs shown above. A special test tank was built to pressure-test each bundle. The Lummus design was faithfully adhered to by top-grade welding and machining skill at the Lummus Honesdale (Pa.) plant where the heat exchangers were fabricated.

A typical job? No, but a typical example of the engineering skill and knowledge that goes into every Lummus-built job—knowledge that is available to you when you look to Lummus for your heat exchanger requirements.

THE LUMMUS COMPANY
Heat Exchanger Division
385 Madison Avenue, New York 17, N. Y.

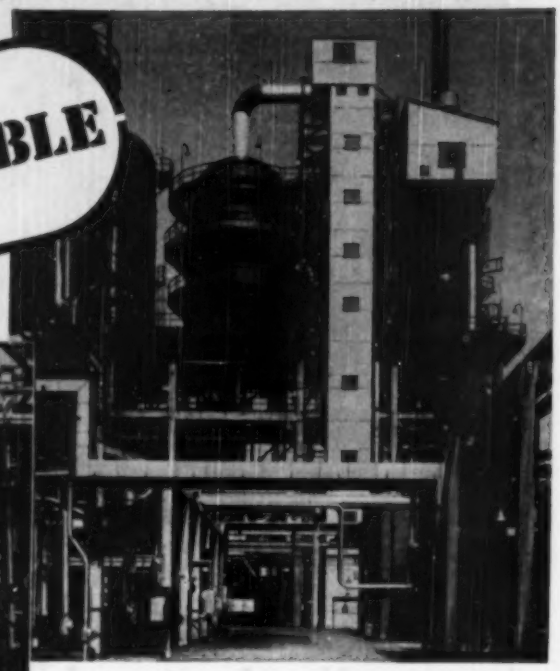
LUMMUS

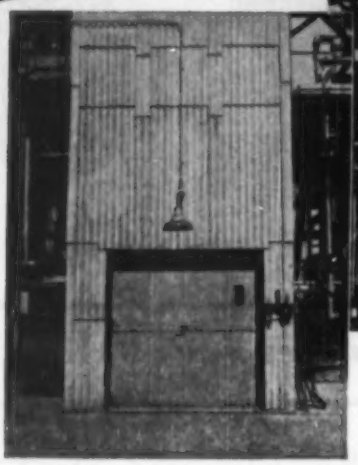
Atlanta • Boston • Chicago • Cleveland
Detroit • Ft. Worth • Houston • Minneapolis • Pittsburgh
Rochester • St. Louis • San Francisco • Wayne (Phila.)
Athens • Buenos Aires • Honolulu • London • Manila
Montreal • Paris • Rome • San Juan, P. R.

LOOK TO LUMMUS for Steam Surface Condensers • Evaporators • Feed Water Heaters • Boiler Blowdown Heat Exchangers Steam Jet Air Ejectors • Steam Jet Refrigeration • Barometric Condensers • Heat Exchangers • Process Condensers • Reboilers Steam Generators (Indirect Fired) • Fuel Oil Heaters • Lubricating Oil Coolers • Pipe Line Coolers • Jacket Water Coolers

K&M *"Century"* ASBESTOS CORRUGATED WALLS

NOT PERISHABLE





Mid-Continent Petroleum Corporation Refinery, West Tulsa, Oklahoma.

Elevator Tower and Penthouse protected by K&M "Century" Asbestos Corrugated, applied with "TOP-SIDE"* Fasteners.

Industrial and commercial building walls need a rugged constitution. That's exactly why K&M "Century" Asbestos Corrugated walls are bound to be an economy for you. They provide all the structural strength and staying power of the proved K&M Asbestos-Cement combination. They shed extremes of weather and other atmospheric threats, without even needing paint. They defy fire, rust, rot, rodents and termites. You can plainly add it all up to long-term freedom from maintenance.

Initial savings are just as plain, for K&M "Century" Asbestos Corrugated goes up fast, no special work needed. Fitting is easy with ordinary cutting and drilling tools. Even scaffolds and extra labor can be eliminated by using "TOP-SIDE"* fasteners. They're made so that K&M Corrugated can be anchored to steel members of any type, on sides or roofs. You'll have protective enclosure—and cost figures—that keep on looking good.

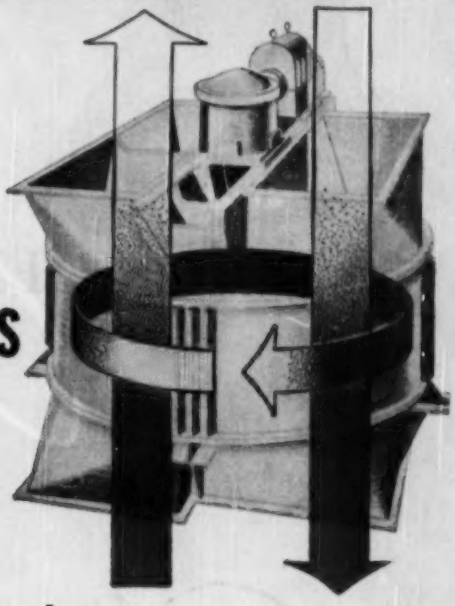
Write for the name of your nearest K&M Distributor, and full data on K&M "Century" Asbestos Corrugated.

*U. S. H. & B. Enterprise Corp.

Nature made Asbestos . . . Keasbey & Mattison has made it serve mankind since 1873

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

How the Ljungstrom Air Preheater can modernize "middle age" boilers



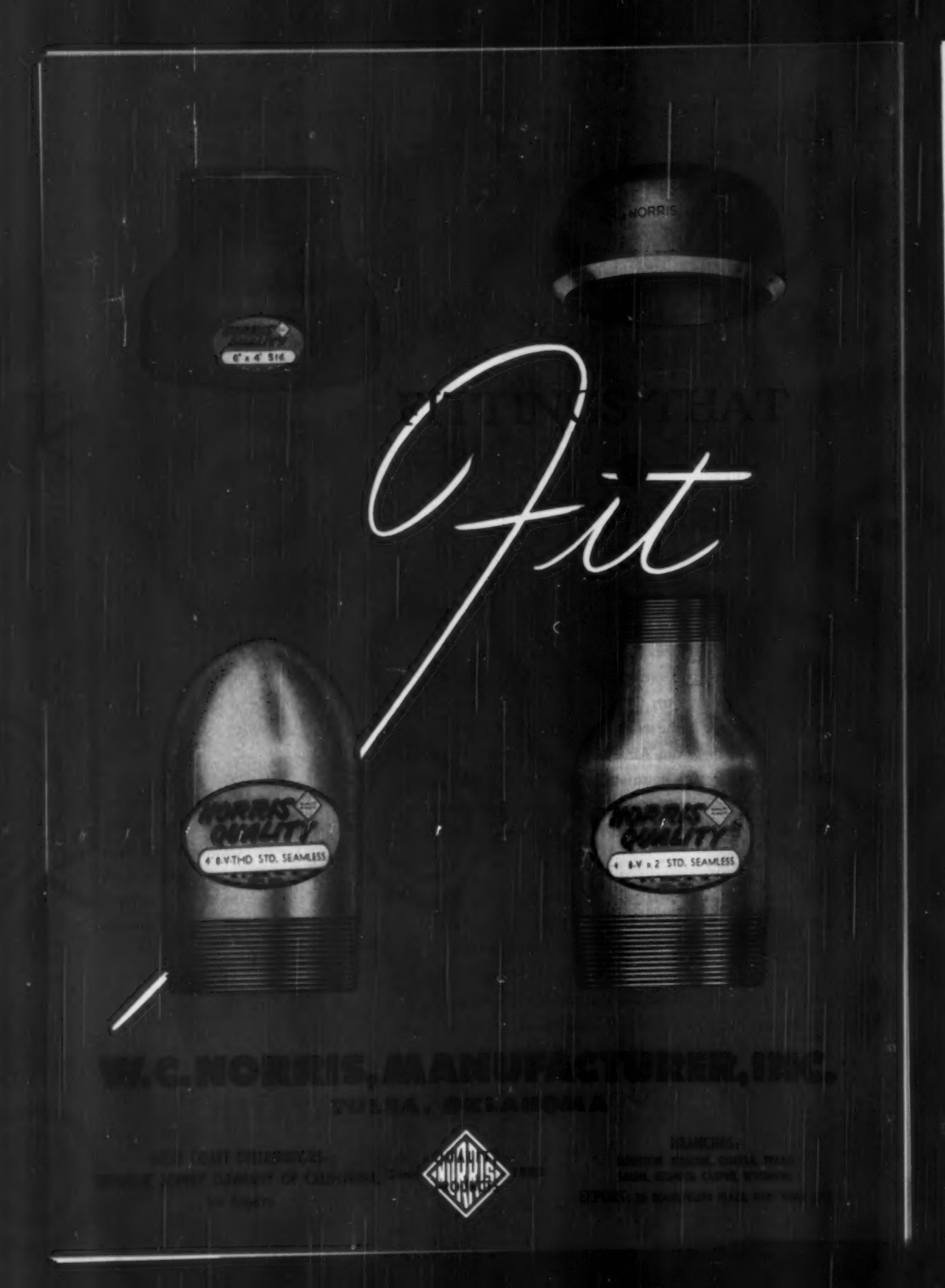
The lightness and compactness of the Ljungstrom Air Preheater makes installation possible on "middle age" boilers with minimum change in the existing structure. This addition of the Ljungstrom Air Preheater, with its continuous regenerative counterflow principle permits operation at lower exit gas temperatures . . . assuring increased heat recovery and reducing the amount of fuel required.

In a matter of a few years the Ljungstrom Air Preheater will effect savings that will more than offset the initial installation cost. If you are interested in approaching modern performance standards with your "middle age" boilers, our engineers will welcome the opportunity to show you how the Ljungstrom can raise the overall efficiency of your plant.

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves the heat is transferred from the waste gases to the incoming cold air.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.



W. C. NORRIS MANUFACTURER, INC.

TULSA, OKLAHOMA

Aiming for higher octanes?

See how THIS Mercaptan Removal Process replaces doctor treating AND

- *reduces TEL requirements*
- *gives you low operating costs*
- *requires a minimum of new equipment*

More than seven years of commercial refinery operation have proved conclusively the high efficiency of the Tannin Solutizer Process* for mercaptan removal. This is the process that brings your equipment up to "new plant" standards in the economical treatment and blending of higher octane gasolines, *without* affecting the stability of the treated product.

Converting to the Tannin Solutizer Process requires a minimum investment in new equipment . . . very likely your present equipment will serve with little change.

Operating economy is an outstanding advantage of the Tannin Solutizer Process. Still another important consideration . . . *this process is not corrosive;* does *not* require equipment of special alloys.

Complete engineering service is available . . . to help plan your unit, to supervise start-up, to assist in later operation if required. We welcome the opportunity to work with you in achieving the many benefits of the Tannin Solutizer Process.

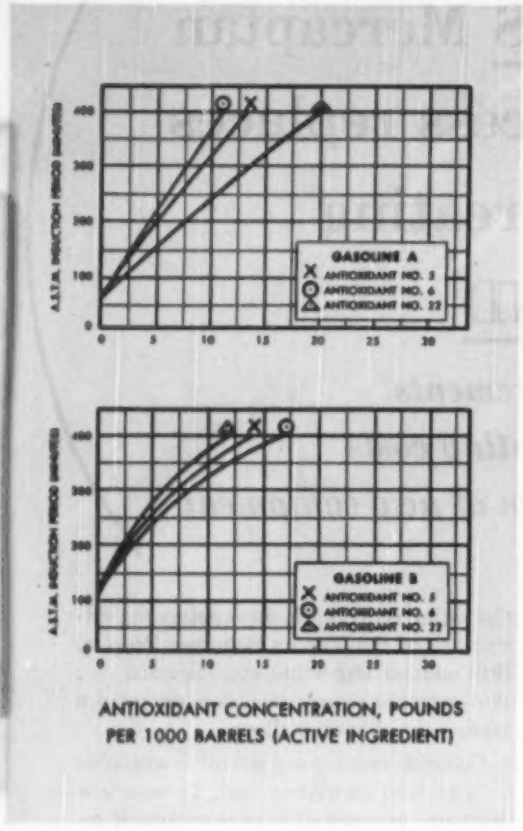
**The Tannin Solutizer Process is licensed under the patent rights of Socony-Vacuum Oil Company and Shell Development Company.*

SHELL DEVELOPMENT COMPANY
50 West 50th Street, New York 20, New York

SHELL

For Lower Treating Costs

Check all three Du Pont Gasoline



The above curves indicate the differences in induction period response of two different stocks to Antioxidants No. 5, No. 6 and No. 22. In stock A, the best response was obtained with Antioxidant No. 6, while in stock B, Antioxidant No. 22 was the most effective.

Regardless of the antioxidant treatment you have been using for your gasoline, it will be well worth your while to investigate thoroughly the three Du Pont Gasoline Antioxidants, Nos. 5, 6 and 22. Each has specific characteristics and usually, under any set of conditions, there is one antioxidant which will prove best for that application.

The relative efficiencies of Antioxidants Nos. 5, 6 and 22, as determined by accelerated laboratory tests such as induction period and "gum time," will vary with the gasoline in which they are tested. While in many gasolines there will be only minor differences in efficiency between the active antioxidant ingredients, in other gasolines the differences are sufficiently great to represent a real saving in cost when the most effective one is used. The curves opposite show marked differences in response between the three antioxidants in two different stocks.

Antioxidants Nos. 5 and 6 are generally to be preferred when control of copper dish gum is important. No. 22, because of its insolubility in water, usually works best where water extraction may be a problem. *To evaluate in your gasolines*—send for or ask your Du Pont Petroleum Chemicals representative for samples. The nearest Du Pont Field Laboratory will also be glad to check your gasoline stocks and recommend the most efficient antioxidant.

MAKE DU PONT THE SOURCE FOR ALL OF YOUR GASOLINE ADDITIVES

Tetraethyl Lead Compounds (Motor Mix—Aviation Mix) • Antioxidants • Metal Deactivator • Dyes

• • •

Antioxidants Nos. 5, 6, 22

No. 5

Antioxidant No. 5 is a solution containing 50% Normal-butyl-para-aminophenol, 30% anhydrous iso-propanol, and 20% anhydrous methanol.

PROPERTIES

Specific Gravity, 75°/75°F.	0.90
Flash Point, °F.	60 (Tag. C.C.)
Viscosity at 100°F, Saybolt Universal Seconds	41
Solidification Temperature, °F.	—20
Range of use concentration, Weight %	0.002 to 0.01
Pounds per 1000 (42 gal.) barrels	5 to 25

No. 6

Antioxidant No. 6 is a solution containing 50% iso-butyl-para-aminophenol, 30% anhydrous iso-propanol, and 20% anhydrous methanol.

PROPERTIES

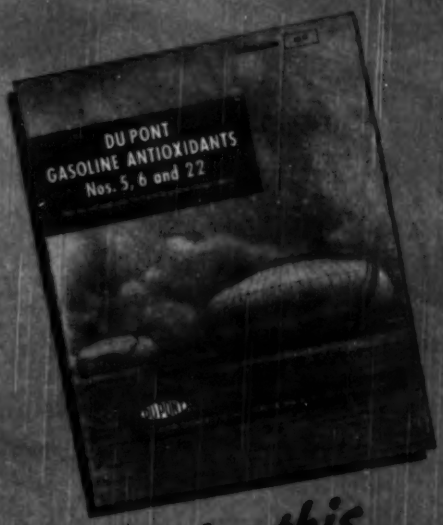
Specific Gravity, 75°/75°F.	0.90
Flash Point, °F.	60 (Tag. C.C.)
Viscosity at 100°F, Saybolt Universal Seconds	41
Solidification Temperature, °F.	0
Range of use concentration, Weight %	0.002 to 0.01
Pounds per 1000 (42 gal.) barrels	5 to 25

No. 22

Antioxidant No. 22 is a commercial grade of N,N'-di-secondary butyl-para-phenylenediamine containing no solvents.

PROPERTIES

Specific Gravity, 75°/75°F.	0.94
Flash Point, °F.	290 (Cleveland Open Cup)
Viscosity at 100°F, Saybolt Universal Seconds	64
Range of use concentration, Weight %	0.001 to 0.005
Pounds per 1000 (42 gal.) barrels	2.5 to 12.5



Send for this New Book!

Recently published, this new 24 page book provides complete information on Du Pont Gasoline Antioxidants. It also contains much helpful information on methods of antioxidant addition, methods of evaluating antioxidants, correct handling procedures and the like. For a copy, ask your Du Pont Petroleum Chemicals representative—or write the nearest District Office.

PARTIAL TABLE OF CONTENTS—

- History of antioxidant development
- Du Pont Gasoline Antioxidants —Composition and physical properties
- Mechanism of oxidation and function of the antioxidant
- Antioxidant efficiency
- Effect of treating on antioxidant response
- Methods of evaluation
- Point of antioxidant addition
- Methods of antioxidant addition
- Safe handling practices

Petroleum Chemicals

DU PONT
REG. U.S. PAT. OFF.
Better Things For Better Living ...Through Chemistry

E. I. DU PONT DE NEMOURS & COMPANY (INC.)
Petroleum Chemicals Division • Wilmington 98, Delaware

District Offices: New York, N. Y. · Chicago, Ill. · Tulsa, Okla. · Houston, Texas · Los Angeles, Calif.

District Laboratories: Wilmington, Del. · Chicago, Ill. · Tulsa, Okla. · Houston, Texas · El Monte, Calif.

CALL ON "MAINTENANCE"

FOR YOUR REQUIREMENTS OF HIGH PRESSURE SPECIALTIES

Large Houston stocks of the following nationally-recognized products:

- **STAINLESS STEEL** Stud Bolts, Nuts, Cap Screws, Ells, Tees, Unions, Couplings, as well as forged Steel, 3000- and 6000-lb. working pressure.
- **MASON-NEILAN** Reducing and Back Pressure Regulators—Liquid Level Controllers—all types for Oil, Gas, Steam or Water service.
- **CAST STEEL** Flanged End Gate Valves, Forged Steel Globe Valves, Gate and Check Valves.
- **SEAMLESS STEEL** Tube-Turn Welding Fittings, Ells, Tees, Caps and Reducers; Forged Steel Flanges—threaded, slip-on, welding neck, and blind—in sizes from ½" to 24" O.D.
- **HAGAN** Control Equipment, Hall Laboratories Water Conditioning.
- **NATIONAL** Seamless Steel Pressure Tubing, Seamless Steel Heat Exchanger and Condenser Tubes.
- **SMITH** Meters and SPARLING Meters, for your measuring problems in oil, gas, water, and other liquids.

YOUR INQUIRY IS INVITED

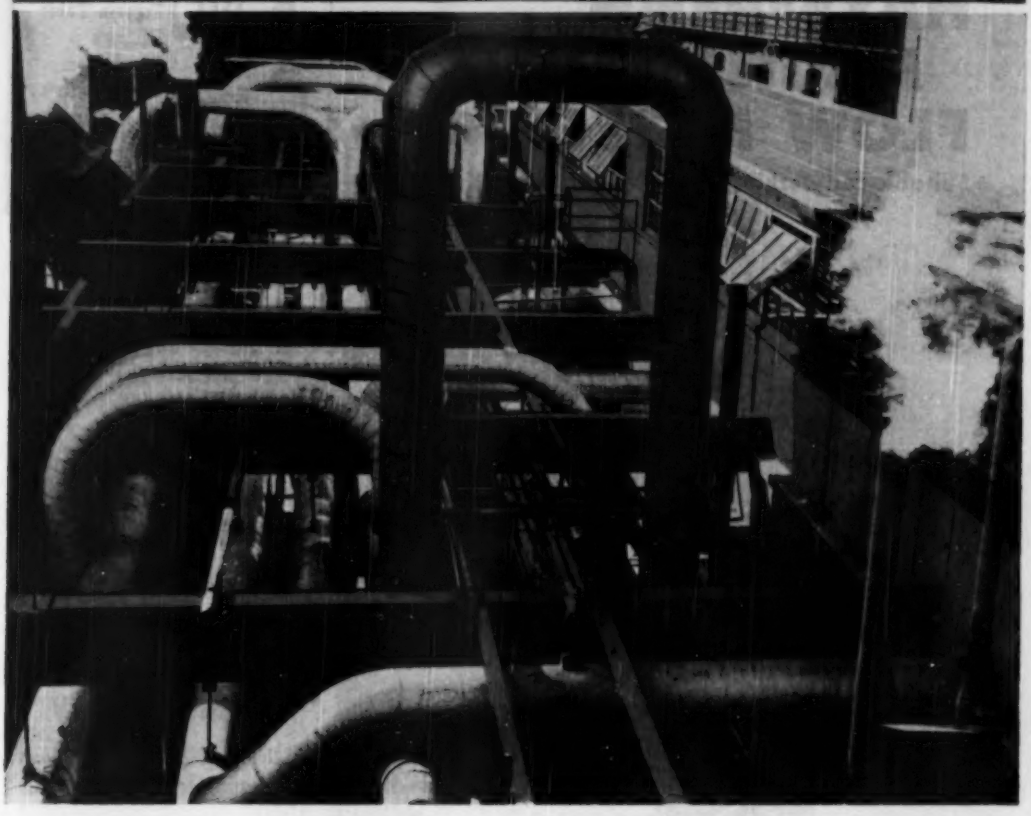
MAINTENANCE ENGINEERING CORPORATION

3611 CLINTON DRIVE
P. O. BOX 9637
HOUSTON 1, TEXAS

EQUIPMENT WITH ENGINEERING SERVICE

MECO

RIC-WIL FOILCLAD INSULATED PIPING



for
PERFECT PRODUCT CONTROL

For intricate exposed piping installations which must insure absolute processing temperature control, the first choice is Ric-Wil Foilclad.

The exclusive Foilclad construction of insulation and protective coatings guarantees long and trouble-free system operation for industrial users. For years Foilclad Insulated Piping Systems have been conveying all kinds of processing liquids in intricate but efficient piping networks.

The knowledge gained from forty years' experience in designing, engineering, and producing Ric-Wil Insulated Piping guarantees the industrial user a superior system to fit his specific requirements.

Upon request, our representative will provide detailed Ric-Wil information as applied to your current problem.

For full technical information on Ric-wil Insulated Piping Systems, call or write the Ric-wil office nearest you or Dept. 6-C in Cleveland, Ohio.

Ric-wil
INSULATED PIPING SYSTEMS

OVERHEAD — **THE RIC-WIL COMPANY · CLEVELAND, O.** — UNDERGROUND

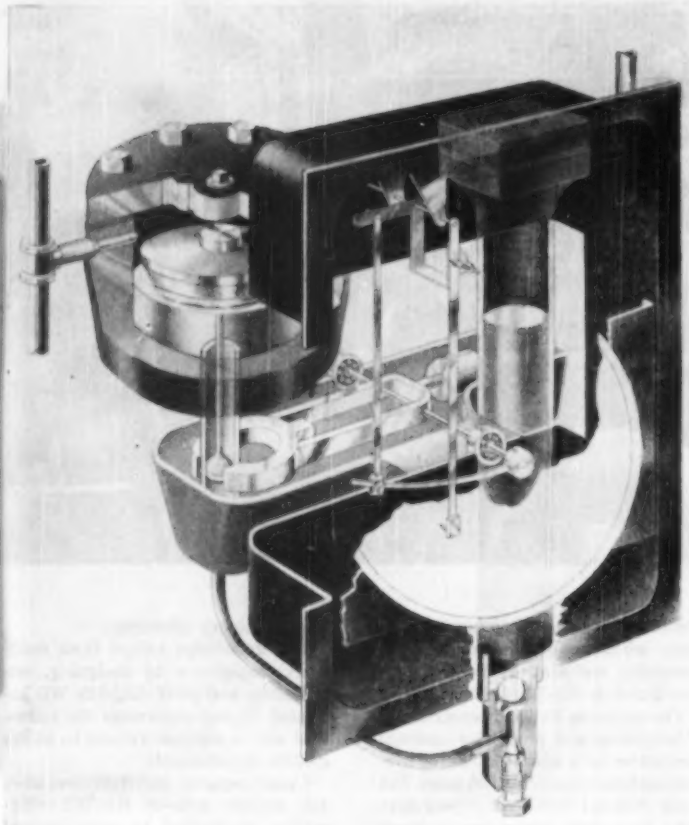
FOR FORTY YEARS THE GREATEST NAME IN INSULATED PIPING SYSTEMS

HAYS-PENN MAGNA CLUTCH FLOW METERS

Suitable for working pressures up to 2500 psi

NO Stuffing Box
Torsion Tubes
Bellows
Diaphragm
Pressure-tight Bearing

therefore
NO HYSTERESIS



Highest accuracy

Maximum power provided by large float and long float travel

Minimum friction because of magnetic coupling

Ambient temperature compensation

Precise calibration check at 50%

Complete safety

No leakage possible of explosive, inflammable, or toxic fluids

Great flexibility

5 interchangeable range tubes 17 to 750" with easy range adjustment over entire span

Lowest maintenance

Fully accessible manometer...Only one internal moving part (the float)... No bearing to service...Mercury volume and level not critical...Positive mercury check valves...Mercury easily drained.

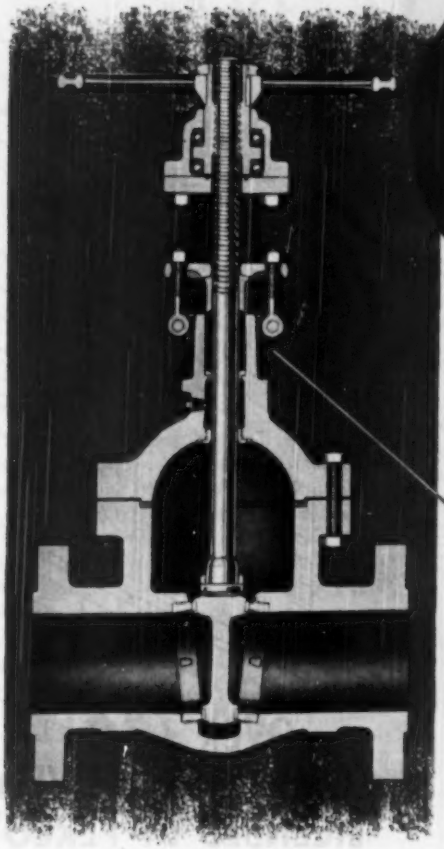
Write for:
Bulletin 50-915

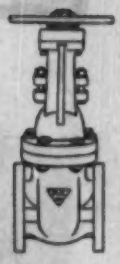
THE HAYS CORPORATION *MICHIGAN CITY 10, INDIANA* • Automatic Combustion Control • Boiler Panels •

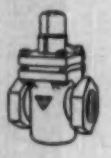
Hays-Penn Flowmeters • Veriflow Meters and Veritrol • Gas Analyzers • Draft Gages • Combustion Test Sets • CO_2 Recorders • Electronic Oxygen Recorders

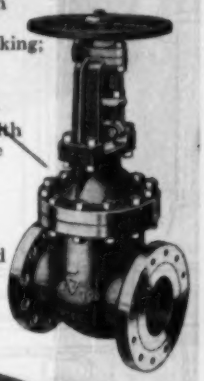
You'll benefit by using

R·P&C
CAST STEEL VALVES









Note the **quality features** of this Gate Valve. They are typical of all valves in the R-P&C Cast Steel Line—gate, globe, angle and check valves in pressure classes 150 lb. through 1500 lb.

- **Ball Bearing Operating Nut** permits smooth operation with minimum effort.
- **One Piece Yoke with Cap** provides rigidity, perfect alignment and easy access to operating nut.
- **High-Quality Packing** assures a tight stuffing box under all conditions—low stem friction—minimum servicing.
- **Gland and Follower with Ball Joint** applies uniform pressure on packing, prevents follower binding with stem.
- **Heat-treated Stainless Steel Stem** has high strength and corrosion resistance. Polished surface increases life of packing; T-head makes strong, self-aligning connection with wedge.
- **Solid I-Beam Wedge** is guided to proper seating by guide ribs cast integral with the body. Wedge seating surfaces are precision ground to fit perfectly with body seat rings.
- **Barrel-type Seat Rings** have heavy, uniform section; offer no points of high stress concentration; have broad seating surface, ground smooth for less wear—longer life. Port opening is full pipe diameter

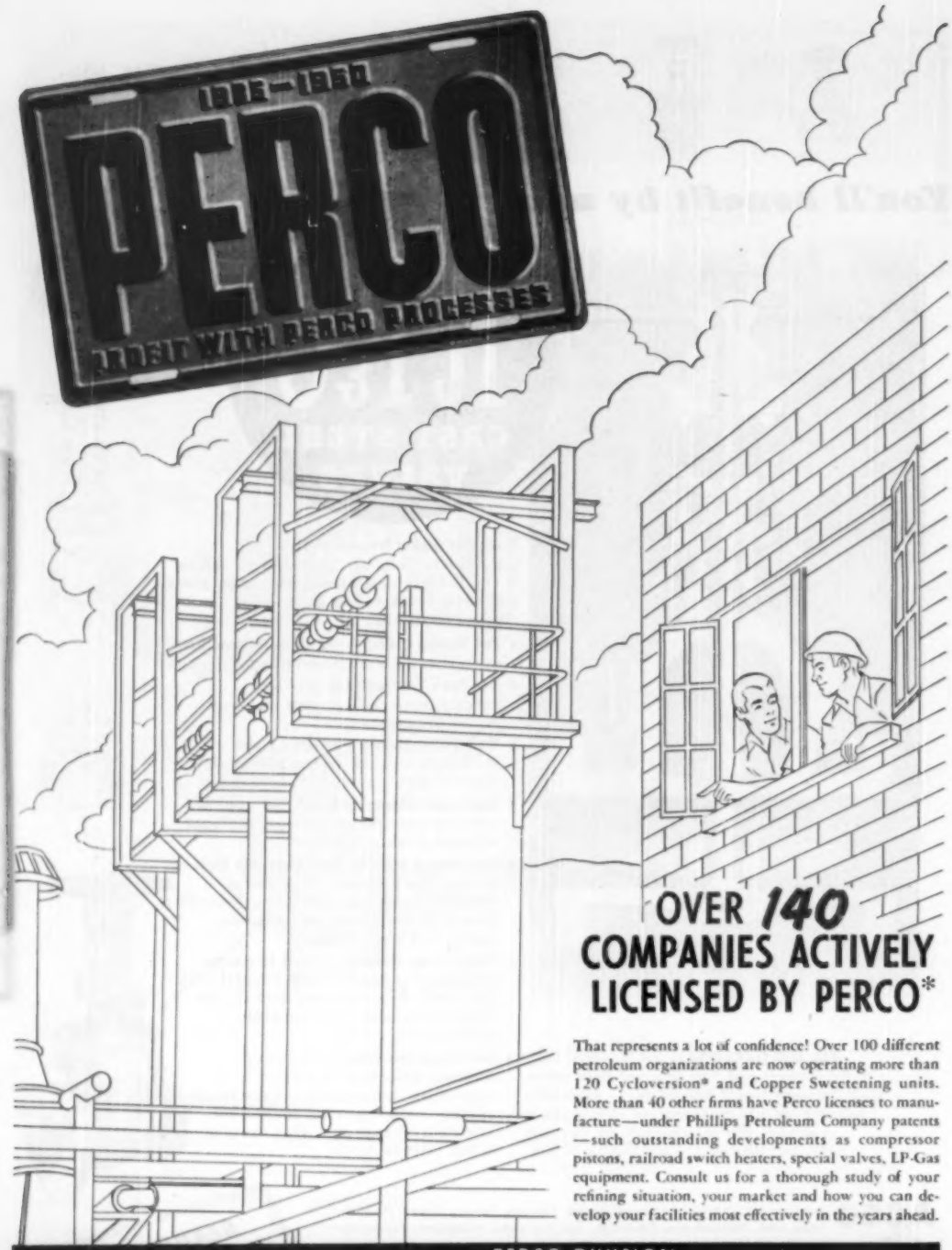
***In addition** to the standard line, R-P&C offers cast steel gate and globe valves with Pressure Sealed Bonnet joint—especially adapted for high pressure, high temperature service. For information, get in touch with your nearest R-P&C District Office.*

ACCO Reading, Pa., Atlanta, Baltimore, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Connecticut

R-P & C VALVE DIVISION
AMERICAN CHAIN & CABLE

TRADE MARK

READING-PRATT & CADY VALVES



OVER *140* COMPANIES ACTIVELY LICENSED BY PERCO*

That represents a lot of confidence! Over 100 different petroleum organizations are now operating more than 120 Cycloversion* and Copper Sweetening units. More than 40 other firms have Perco licenses to manufacture—under Phillips Petroleum Company patents—such outstanding developments as compressor pistons, railroad switch heaters, special valves, LP-Gas equipment. Consult us for a thorough study of your refining situation, your market and how you can develop your facilities most effectively in the years ahead.

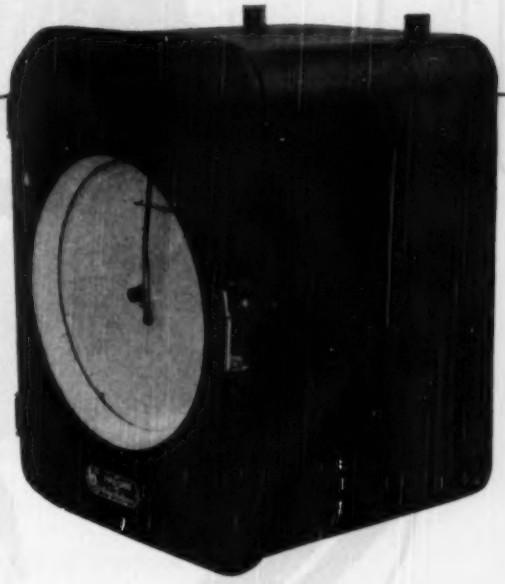
* SERVICE MARK

PERCO DIVISION

PHILLIPS PETROLEUM COMPANY

BARTLESVILLE, OKLAHOMA

HIGH DIFFERENTIALS
ARE NO PROBLEM
with HAGAN
Ring Balance Meters



With ordinary meters, high differential pressures present serious difficulties—but not with the Hagan Ring Balance Meter.

Hagan meters for differentials up to 420 inches of water require exactly the same size case as low-differential meters. There is no drop leg, no U tube—everything is inside the case.

With both high-differential and low-differential Hagan Ring Balance Meters, checking and calibration are done by the same simple method, using a set of check weights which are furnished with the meter. The water column method, which is especially cumbersome when high differentials are involved, is unnecessary, and it offers no routine advantages over the check weight method.

For full information on Hagan Ring Balance Meters, fill in the coupon below or write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pennsylvania.

HAGAN CORPORATION

RING BALANCE FLOW AND PRESSURE INSTRUMENTS
THRUSTORQ FORCE MEASURING DEVICES
BOILER COMBUSTION CONTROL SYSTEMS
METALLURGICAL FURNACE CONTROL SYSTEMS

Hagan Corporation
Hagan Building
Pittsburgh 30, Pennsylvania

Please send me further information on Hagan Ring Balance Meters. I am particularly interested in_____

NAME_____

POSITION_____

COMPANY_____

STREET AND NUMBER_____

CITY_____ ZONE____ STATE_____

PR 10

NOW SEVEN UNITS

Since the first of the UOP Platforming units went on stream at the Muskegon, Michigan, refinery of Old Dutch Refining Company in October of 1949, six more progressive-thinking refiners have turned to this new process for the octane improvement of straight run gasolines. • These six additional units now planned or under construction, will offer the

where

PLATFORMATE

pays off!

Blend *your* gasoline with Platformate, the product of the UOP Platforming process, and watch it pay off . . . in terms of increased gallonage.

Platformate is a blending component that boosts product quality even when your gasoline is made from the poorest stocks. Road octane of Platformate itself, when produced from the lowest octane naphthas (with 3 cc of lead) is rated nearly 100.

Platformate is inherently stable and negligible in sulfur content. There is more energy per gallon. The odor is pleasant. Production is economical.

Where increased gallonage depends on improved quality, depend on Platformate.

UNIVERSAL OIL PRODUCTS COMPANY

General Offices: 310 S. MICHIGAN AVENUE, CHICAGO 4, ILL., U.S.A.
LABORATORIES: RIVERSIDE, ILLINOIS

Universal Service Protects Your Refinery

same advantages which have been proved so conclusively by the commercial operation of the first unit at Muskegon . . . advantages which include the improvement of straight run gasoline to better-than-premium-quality and the resulting increase in gallonage at the point of sale. • Old Dutch has proved the point. Now six more refiners have specified Platforming. When will you do the same?

DOWELL

SPECIALISTS IN SCALE AND SLUDGE REMOVAL WITH CHEMICALS

Cleaned! 757 cu. ft. of scale removed in 30 hours

Complex construction of Open Box Condenser is no problem for Dowell Chemical Scale Removal Service

An open box condenser at a Midwestern oil refinery was heavily coated with scale. *Within 30 hours*, Dowell Service removed an estimated *757 cu. ft.* of scale and the condenser was back in service!

Fast, effective cleaning of industrial heat exchange equipment is made possible by Dowell Service. Carefully selected solvents penetrate wherever water flows and are designed to remove troublesome scale from all surfaces contacted. Costly dismantling or modification is not required—the necessary solvents are pumped into the equipment using existing connections. When the scale is dissolved or disintegrated, the spent solution is pumped out, the unit flushed and put back in service. Expensive down time is held to a minimum.

Whenever you have a scale removing problem, look to Dowell. Experienced Dowell engineers do the job, bringing the equipment necessary to insure proper control at every stage of the operation.

Call the nearest Dowell office today for details about the fast, effective, and economical Chemical Scale Removal Service for boilers, heat exchange equipment, condensers, and water lines. Free estimates gladly given.

DOWELL INCORPORATED · TULSA 3, OKLAHOMA

SUBSIDIARY OF THE DOW CHEMICAL COMPANY

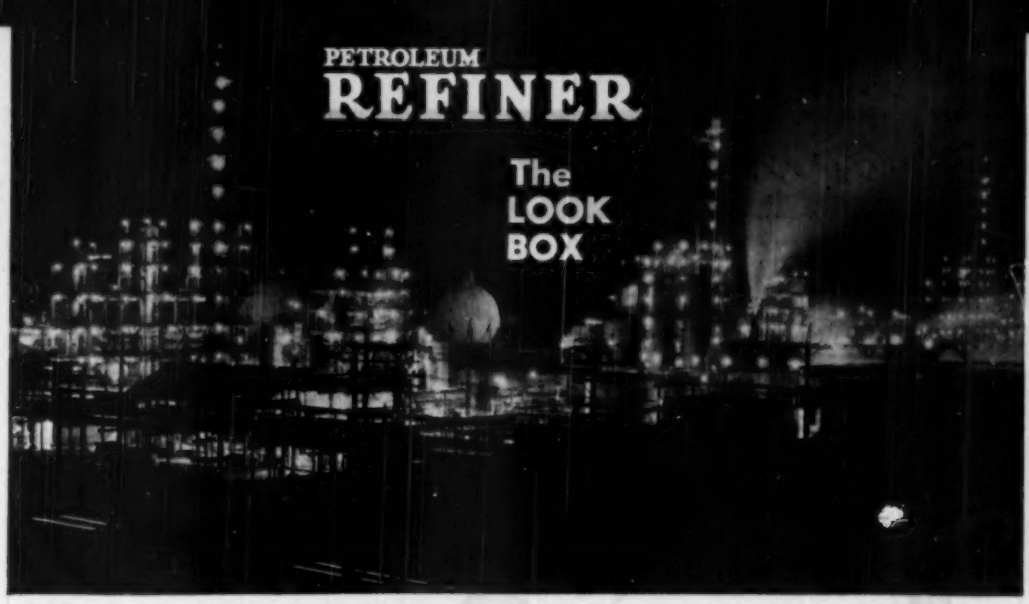
CALL

New York 20 · Boston 16 · Philadelphia 3 · Baltimore 18 · Wilmington 99 · Richmond 19 · Atlanta · Buffalo 2 · Cleveland 13 · Pittsburgh 19 · Detroit 2 · Chicago 3 · St. Louis 8 · Indianapolis · Louisville · Kansas City 8 · Wichita 2 · Oklahoma City 2 · Houston 2 · New Orleans 12 · Ft. Worth 2 · Shreveport 23 · Anniston, Alabama · Mt. Pleasant, Mich. · Hamilton, Ohio · Charleston 27, W. Va. · Salem, Illinois · Borger, Texas · Midland, Texas · Wichita Falls, Texas · Lafayette, La.

Long Beach, Oakland, Casper: Dowell Associate—International Cementers, Inc.

DOWELL

A SERVICE ORGANIZATION



Editorial AND Advertising Pages

WHEN we of the PETROLEUM REFINER's staff had completed reading the September Issue of PETROLEUM REFINER — the issue in which a special section was devoted to new processes or processes which have been improved during the past 12 months—we felt that we should take off our hats to a group of men who contributed every bit as interesting information in it as did we of the editorial staff.

We are referring to the more than 100 advertising departments and advertising agencies who prepared the advertising copy for the September issue. The advertising in that issue literally bristled with information. In fact, on more than one page we of the editorial staff saw where we had been scooped by the advertising departments of various concerns.

We think that PETROLEUM REFINER readers who tell us from time to time that they find the information in the advertising pages of fully as much value as the information in the editorial pages, will be especially impressed by the thought and work which went into the advertising pages of the September issue. If you haven't made a page-by-page study of it, you owe it to yourself to do so.

Process Controls

RADICAL changes have occurred in the process control field in the past two years. First, the long known but little used graphic panel concept was reworked by an engineering company instrument man to suit the needs of today's process plants. A manufacturer was found to develop instruments small enough for use directly in control panel flow diagrams. When the ideas met with enthusiastic acceptance on the part of operating companies, other instrument manufacturers rushed into the design and fabrication of small panel space control instruments. At the fifth National Instrument Conference and Exhibit, which was held in Buffalo, N. Y., September 18 through 22, several of these new instruments were on display—some of them for the first time.

Something else new in process plant instrumentation was reported at this Buffalo meeting. E. J. Grace of Sun Oil Company described a process monitoring scheme that uses stepping switches and telephone type dial system instead of the usual multitude of key switches. The various physical measurements in the process unit are converted into electrical units for measurement from a central point.

The present installation is providing temperature measurements from process unit thermocouples. A minimum of wiring and of panel space is needed—and the system is regarded by some as representing real progress toward the achievement of really automatic operation of oil industry process units. Certainly the use of this system does indicate a trend on the part of instrument system designers to utilize more compact apparatus.

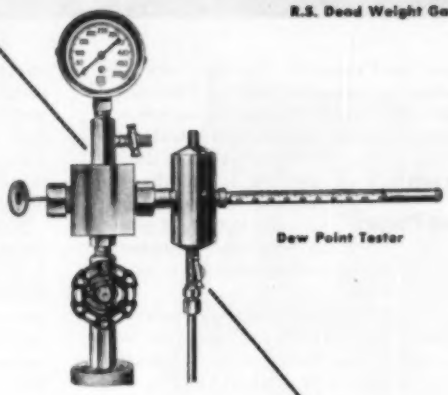
There is extensive speculation, too, that electrical process control apparatus may come into wider use. It is said that the increased complexity of modern process units with centralized control imposes a severe problem in the layout and maintenance of pneumatic piping systems, and that the wiring of electrical control gear is less difficult.

Over the years an extensive "know how" has been developed in this business of automatic process control instrumentation. There have been countless variations in individual design details, but instrument engineers in recent years have tended to use similar arrangements and apparatus for the solution of similar plant applica-

Top of Page Photo—Brilliance of the Lighting of the Alkylation Units at Esso Standard Oil Company's Refinery, Baton Rouge, La. Standard Oil Company (New Jersey) photo.

Specialties for REFINERS

R.S. Dead Weight Gauge



Dew Point Tester

Yel-O-Back Thermometer

LIQUID TESTING INSTRUMENTS
Liquid Gravitometer
Vapor Pressure Bombs
Pressure Hydrometer Jar
Specific Gravity Bombs
Corrosion Test Bombs

DEAD WEIGHT INSTRUMENTS
Standard Dead Weight Gauge
Portable Dead Weight Tester

GAS TESTING INSTRUMENTS
Recording Gravitometer
Specific Gravity Balance
Dew Point Tester
Super Compressibility Apparatus

INDUSTRIAL THERMOMETERS
Indicating Well-Type Thermometers
Indicating Laboratory Thermometers
Recording Thermometers

For Further Information Write for Bulletin No. 50

Refinery Supply Co.
621-23 E. 4th St. Tulsa 3, Oklahoma
Laboratory Apparatus
Instruments Chemicals
MANUFACTURER OF R.S. SPECIALTIES

tion problems. A certain appearance of stability has been achieved. A year or so back, the casual observer might well have concluded the progress in the improvement of process instrumentation would proceed at a slow pace. So much had already been accomplished, and the current equipment and control systems worked so well!

While the results of these trends cannot very well be predicted, it is at least certain that we are to see extensive development of new apparatus in the process controls field.

Fable of The Skylark

OIL men should learn a lesson from the experience of the coal industry, and avoid industry-wide bargaining.

The price may be high, but no price is too high, according to Joseph E. Moody, president of the Southern Coal Producers' Association, who told the National Petroleum Association that "industry-wide bargaining will sooner or later lead down the road to socialism and nationalization."

Moody in his address described step by step the course of the coal industry over the last decade. He said it has been forced to give up its position and freedom in the country's competitive economy, and that frequently small concessions paved the way for fateful trends. He explained:

"The willingness of one company to use expediency in its relationship with its employes and the union can eventually lead to where it can no longer control its destiny in a competitive system."

Moody listed 18 concessions granted by the U. S. government during the periods when it controlled the mines from 1943-1947. He pointed out that in the fights waged by owners and management to maintain a balance of power and control of the industry, the final decision was the result of government intervention.

"Recent contract negotiations on all points have become farcial," he stated. "We have reached the point where collective bargaining does not exist."

To emphasize the difficulty of stopping or reversing a trend in labor relations, Moody told the fable of the skylark who traded his feathers one at a time to a peddler for worms. When it was too late, the skylark realized it had lost its ability to fly. It tried to get the peddler to return the feathers for worms, but this the peddler refused to do.

"The bargaining away of freedom may be carried to the point where the government itself may have feathers plucked in return for labor support," he declared.

Moody briefly listed the negotiations of his association with the United Mine Workers from 1947-1949 pointing to the hopelessness of finding common ground with a union which insists on a national contract without consideration for special regional and within-industry situations and conditions.

"On March 3, 1949, a deal was made but the Southern Coal Producers' Association was not advised of it until after it was consummated between Lewis and the Northern group," he stated. "Then after 10 months of fighting, the association was again maneuvered into another industry-wide contract.

"It is a long fight. We believe it is one that must be brought to a successful conclusion if the coal industry of the United States is to be kept as a private industry."

Moody's warning is a danger which the oil industry has long realized, but for so serious a problem such alerts cannot be sounded too frequently. Or with too much vigor.

There is a considerable group of fuzzy-minded people who are engineering a compromise between free men and certain European infections. They fail to realize that our American system has grown away from the systems of Europe for 250 years. They have the foolish notion that a collectivist economy can at the same time preserve personal liberty and constitutional government. That cannot be done.

—HERBERT HOOVER.

Bigness In Peace And War

STOCKHOLDERS of Socony-Vacuum Oil Company, Inc., last month received from George V. Holton, chairman, board of directors, a folder packed with such timely words of wisdom that PETROLEUM REFINER is going to borrow a few and recommend them for thoughtful reading:

"Today's (Korean) emergency is demonstrating the unsoundness and unfairness of haphazard attacks on reputable companies, primarily because they are large. In a very practical sense, integration of our company is another example of looking ahead resulting in preparedness. The coordination of activities which makes for competitive efficiency in peacetime enables us to respond at maximum speed to the sudden demands of war. Already, in more than one instance, the Administration has turned for help in war to the very companies being attacked for 'bigness' in peace. That, too, is something we should not forget, or let others forget, when the fighting is over.

"We do not know just where the Korean conflict will lead. We do know that under pleas for preparedness all sorts of government controls will be advocated, many of which if adopted and continued would inevitably lead to just the Communistic state we are fighting to avoid. We know too that if not hamstrung by such controls American business, big and small, will play a major part both in helping to win the military battles and in maintaining the nation's economic strength on which our freedom is based."

IT'S YOURS

with facts worth knowing about STEEL and ALLOY PLATE fabrication

...plus comprehensive Corrosion Data Charts

This new 1950 Catalog contains 16 pages illustrating and explaining the many specialized techniques and services of the Nooter Corporation in the fabrication of tanks and vessels for the petroleum and processing industries. "Beyond Your Blueprints" also features an extensive section of valuable Corrosion Data Charts showing resistance of commonly-used metals to hundreds of chemicals.

NOOTER CORPORATION
1404 S. Second St., St. Louis 4, Mo.

Gentlemen: Please send us Your 1950 Catalog, "Beyond Your Blueprints"

..... Name ..... Title

..... Company Name

..... Address

..... City ..... Zone ..... State

MEMO TO WASHINGTON—

No Time Now for Manipulations And Socialistic Experiments!

A. L. NICKERSON
Socony-Vacuum Oil Company, New York

PROPOSED divorcement of marketing operations from integrated oil companies are not in the public interest in time of peace. And in time of war or threatened war the prosecution of socialistic experiments by economic theorists is offering aid and comfort to our enemies.

These are the conclusions made by Mr. Nickerson, director in charge of domestic marketing, Socony-Vacuum Oil Co., Inc., last month at the annual meeting of the National Petroleum Association, the main points of whose address is presented here.

IN 1949, 57 percent of the total power energy consumed in the United States was derived from the petroleum and natural gas industries. This compares with 8 percent from the same sources in 1900 and 18 percent in 1920.

Statistics relating to total energy are most impressive to indicate the essentiality of the petroleum industry to the people of the U. S.—particularly so when it is understood how energy requirements have increased in the recent past and when it is appreciated that in virtually every instance oil can be substituted over a reasonable period for coal or water power. The reverse is not true except insofar as heating use and stationary power station operation are concerned.

The increases in standards of living of various countries can be measured in terms of total energy used. In 1948, Europe used no more energy than it did in 1938 while, in the same ten-year period, the energy requirements in the U. S. increased by 76 percent. The percentage of energy supplied by the petroleum industry in this country has increased steadily above other energy sources.

The appetite of the American people for more and more oil continues to grow. Our per capita consumption of oil products in 1949 is about 30 percent greater than it was in 1941.

One Hundred Million Dollars on Research

To determine the efficiency with which the oil industry discharges its responsibilities, there are four standards against which the industry's general performance must be measured:

1) Adequacy of the *quality* once the industry has made the *quantity* of the products available. The industry is spending in excess of $100 million a year and employing over 15,000 scientists on its research effort. Its success is attested by the constant improvement in quality of existing products and the new products that are being used.

With respect to quantity, the total domestic demand for petroleum products has increased 364 percent between 1920 and 1949 and no intervening 10-year period has shown an increase of less than 43 percent. While fully satisfying this colossal demand, the industry has increased its proved reserves to 28 billion 600 million barrels, including natural gas liquids—the highest figure in its history.

2) *Pricing policies.* Up to July, 1950, the cost of living jumped 72 percent over the 1935-1939 average. During the same time, the cost to the consumer for the major petroleum products (gasoline, distillate fuel, and residual oil) increased only 48 percent. During the last ten years—the years of inflation—the cost of the major products has remained consistently below the cost of living index.

Gasoline Consumption Up 738 Percent

Prices for petroleum products were at levels which encouraged their use as well as contributed to the growth of other industries. For example, the consumption of gasoline increased 738 percent between 1920 and 1949 and no intervening decade shows an increase of less than 48 percent. During the period 1920-1949 the number of motor vehicles in operation increased 381 percent and it is estimated that more than 3,500,000 more vehicles will be added this year. Similar statistics could be offered with respect to diesel engines and central heating plants as well as others.

3) *Wages and working conditions.* The oil industry pioneered in the development of annuities and other benefit plans for its employes. It has provided extremely stable employment. Its safety record is outstanding and in the month of June, 1950, the hourly wage rate in crude production was $1.79, petroleum refining was $1.91, compared with $1.45 in manufacturing industry generally.

4) *Return on investment.* At present, the industry is making a profit of slightly over one cent a gallon—compensation for finding oil, producing it, refining, transporting, storing, and marketing. This profit of one cent a gallon compares with about 2.5c a gallon taxes of all kinds (including gasoline sales tax) imposed by all levels of government. Compared with manufacturing industry generally, there is only one year in the last ten when the petroleum industry earned a greater return on its investment—1948. On the average, the oil industry earned between one and two percent less a year. There was no year when it earned less than 6.3 percent, and a simple arithmetic average of its 10-year earnings ratio was 10.9 percent a year. Were these figures adjusted in terms of 1935-1939 dollars, the rates of return would be substantially reduced.

In the face of this record, we should not be accused of excessive earnings. Our earnings were reasonable and were probably somewhat less than they should have been in the light of the rapid expansion the industry had to face and the magnitude of the financing problems it had to solve.

At this association's Cleveland meeting last spring, Dr. Robert E. Wilson of Standard Oil Company (Indiana) described the competitive struggle in which his company has been engaged in its original marketing territory. Our experience has been similar. For example, we have been doing business in New York state since 1882. We are familiar with the characteristics of this market and are well equipped to supply it, yet our gasoline marketing position dropped from 34 in 1931 to 22 percent in 1949. Surely this is evidence of competition. At the same time we were losing position in our original marketing territory, we were expanding our program into new areas and new states, thereby bringing competitive pressure to bear on the original operators in those areas.

Many Examples of Competition

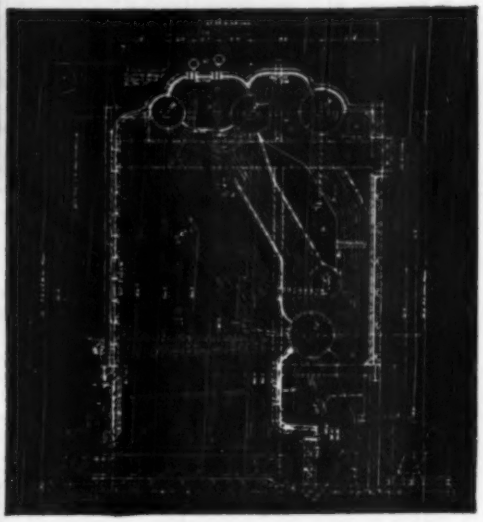
Since the war, in the Eastern market alone we have noted that two new competitors have entered the market—Calso, a subsidiary of Standard Oil of California, and Crown, a marketing company. A number of companies have

Quick Steaming at all Ratings!

Carry high overloads with high efficiency

SPECIFY Vogt

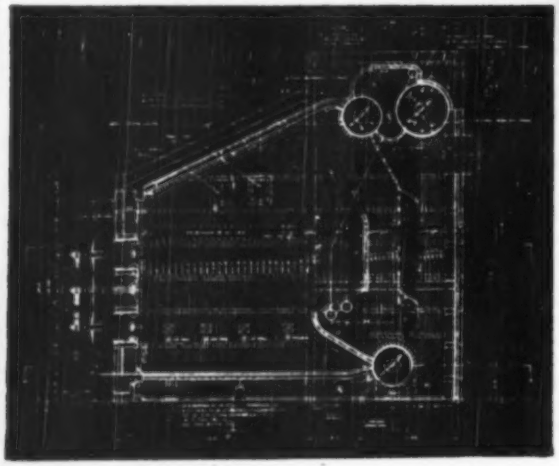
STEAM GENERATING UNITS



CLASS VL Two 27,500 pounds per hour units, installed at Brown-Forman Distillers Corporation, Louisville, Ky. Features large furnace volume in limited space, with high ratio of radiant heating surface.

CLASS LE Mt. Carmel Public Utility, Mt. Carmel, Illinois, is served by this 60,000 pounds per hour unit. Generous steam liberating surfaces and steam space permit wide fluctuations in load.

CLASS VR 70,000 pounds per hour steam generator at Humble Oil and Refining Company, Johnson, Texas. An efficient, high-duty unit with water cooled furnace, using refinery gas fuel.



Vogt builds a complete line of bent tube steam generators, designed to burn solid, liquid, or gaseous fuels to meet specific operating conditions. Superheaters, air preheaters, economizers, water walls, and soot blowers can be readily incorporated. Bulletins with general information and showing typical installations are available upon request.

HENRY VOGT MACHINE CO.

LOUISVILLE 10, KENTUCKY

BRANCH OFFICES:
NEW YORK, PHILADELPHIA, CLEVELAND
CHICAGO ST. LOUIS, DALLAS

Asks Washington's Help in Meeting Military Demand for Aviation Gas; Alkylation Plants Seem Bottleneck

The oil industry can meet U. S. military's heavy demands for aviation "if government helps as much as possible and hinders as little as possible." Success, however, is being seriously threatened by fear of prosecution from the Justice Department.

Bruce K. Brown, head of the Interior Department's military Petroleum Advisory Board and president of Pan-Am Southern Corporation thus outlined the situation before the AIME sessions in New Orleans late last month. He was particularly critical of the department's suit against West Coast oil companies. The industry "wants to work for Uncle Sam without having to fight him for its life at the same time," he said.

Two factors make the aviation gasoline situation critical, Brown declared:

(1) Increased civilian consumption of ingredients that go into making higher quality gasoline, this because motor gasoline itself is now of higher quality and because there are more cars on the road.

(2) Advance in aviation technology, causing modern planes to require more fuel and fuel of higher quality. Specifications for 100 octane aviation gas calls for 85 percent alkylate compared with only 35 percent in World War II specifications. It takes twice as much alkylate per gallon to produce today's plane fuel as was needed in World War II; so refiners "are hard put in 1950 to produce even half as much aviation gas as it did in 1945."

Brown said all of the refineries' present alkylation plants will have to run at capacity "to produce even the relatively small quantity of aviation gas required for the present period." If all this demand for aviation gasoline ingredients are met solely by refineries having alkylation plants, these producers will have to lower the quality of their motor gasolines considerably while other producers would not suffer, he pointed out.

Brown vigorously advocated a government oil agency manned by oil men "and dedicated to the proposition of supplying the military — not to the accomplishment of further socialism by indirection."

erected tanker terminal facilities. It might not be amiss to mention the gasoline price war in New Jersey that has been attracting much attention recently, although this is only one of a number of such price disturbances that have occurred lately throughout the United States. Some of the individuals who have characterized our industry as noncompetitive should try their hand at the operation of a company engaged in some phase—any phase of it.

Government's Charges Against the Industry

Our industry is not perfect, or—for that matter—no business component of it is perfect. It would seem, however, that good performance is entitled to recognition, at least.

Such is not the case. The administration, through various of its executive and regulatory agencies with what appear to be political and/or ideological ends in view, has launched one attack after another at various phases of the industry, the latest being a suit against seven West Coast companies. I would like to spend a little time on one aspect of the Justice Department's complaint—a requirement that each of the defendants retire completely from the business of wholesaling and retailing any and all refined petroleum products except that type of wholesaling carried on at refineries and marine terminals. This section of the complaint, destructive and radical though it is, has been characterized informally by members of the Justice Department as the opening gun in a battle completely to disintegrate the industry.

To be in the public interest, the successful prosecution of this phase of the complaint would have to result in a lowering of the price of petroleum products to the general public or in an improvement of the service, or both. Let us see, by means of a brief analysis of the probable results of marketing divorcement.

It might be said—and with some justification—that the employes affected by divorcement would not suffer. It certainly would not take fewer employes to carry on the activities of the newly formed marketing companies. It would in all likelihood require more.

The marketing departments of integrated companies receive numerous and highly important services from centralized departments and units of their companies, these including services rendered by the comptroller, research, distribution, economics, and public relations departments, to say nothing of the over-all review and analysis of their activities and the guidance that flows to them from top-side executives, officers, and directors. True, the newly formed marketing companies could not afford to replace all these services but some are at least to a certain degree indispensable and to the extent that they were re-created in the new companies, additional employment would be created. And yet, this would not be clear gain for the employes.

The petroleum industry enjoys a preeminent position in regard to the rates of pay, working conditions, and benefit plans it provides. Indispensably, if divorcement of marketing or disintegration became effective, one powerful and effective force in the general drive to improve the standard of living of the average working man would be made less effective or wiped out altogether.

Stockholders Would Not Benefit

The stockholders' position would not be affected—at least at first—if marketing divorcement became effective. A great many of the stocks of integrated companies are selling substantially below the replacement value of their assets as well as below book value. If, in place of one share of common stock, a shareholder were to receive two or more shares in the resultant companies, it is altogether probable that the combined market values of the new shares would at least equal the old.

If owners or employes are not to be hurt by marketing divorcement, who would be? And why is it a retrograde step?

In brief, the divorcement of marketing is bad because of its effect on the industry's customers, the American public. If the divorcement of marketing is but a step in the ultimate drive for complete disintegration of the industry, it assumes a distinctly dangerous and subversive aspect.

Price Up — Efficiency Down

The effect of marketing divorcement on the industry's customers or the American people—the terms are interchangeable—would be in all probability to increase the prices they would have to pay for its products and to decrease the efficiency of the service. Here are the reasons:

1. Above were cited reasons why employment would be increased. It can be argued that this is a good thing for employes although the point is debatable. Plainley, however, the total expense of bringing product to the ultimate consumer will be increased thereby.

2.) It was mentioned that the services and advice of the top executive officers of the original company would no longer be available to the divorced segment. The scarcity of top-flight executives is a well-recognized problem in industry. Accordingly, this influence could be quite harmful.

3.) In any integrated operation, there is a certain mobility and flexibility of personnel. Employes can be, and are shifted to areas of greater need and greater opportunity. Barriers created by divorcement would virtually destroy this desirable feature of integration.

4.) As mentioned, divorcement would

end certain highly important specialized and centralized functions, such as research, economics, public relations, etc. To the degree that they were replaced, expense would be added; to the extent that they weren't replaced, efficiency would be lost. Let's talk about research.

Persons not familiar with the industry do not recognize the inherent flexibility of a properly organized research department. One research technician, for instance, could at various times be involved with problems emanating from either the producing, manufacturing, or marketing operation of an integrated company.

The ties that exist between the research and marketing departments of any integrated company are many and important. Research depends on marketing for information concerning the trend for the development of new products and the collection of performance data on experimental products, existing products put to new uses, and competitive products. Marketing depends on research for help in the adjustment of consumer complaints and the solution of problems arising from product application or competitive developments, to mention only a few. The industry's customers will miss these exceedingly important benefits that accrue from this relationship.

Duplication of Facilities

5.) Many physical facilites are put to different departmental uses at various times. The erection of a barrier between refining and marketing would inevitably result in duplication of storage and, more importantly, duplication of inventory, a most expensive inefficiency.

6.) One of the greatest advantages that results from integration in the oil business accrues through the ability that is created thereby to plan and schedule supplies of product all the way from well to consumer without unnecessary interruption. The average petroleum product is a highly inflammable, more or less viscous, volatile liquid. It is always enclosed in an expensive container. Its use is subject to seasonal variation. Under normal conditions, there are seasonal surges which often tax the capacity of tank cars, pipe lines, and tankers. Under conditions of divorcement, the close liaison which exists between the manufacturing and marketing levels would tend to deteriorate; forecasting and scheduling would become much less precise. Considerable duplication of facilites would result and, in temporary emergencies, such as that caused by the cold winter of 1947-1948 in the Northeast, interruption of customer service could become very acute.

7.) The winter of 1947-1948 illustrates another potential evil of marketing divorcement. For a brief period of time, largely caused by a temporary shortage of transportation facilities, supply was exceeded by demand in the Northeast. Nevertheless, in defiance of the law of supply and demand, prices did not become unreasonable. Many elements were responsible for the exercise of restraint but surely the integrated companies with their great sensitivity to public reactions deserve much credit.

Integrated Companies Help in Emergencies

8.) During that same winter, the integrated companies went to extremes to bring needed relief. My own company, for example, expended in its Eastern operations alone more than $11 million in extra transportation costs and premiums paid for materials unavailable except at unusually high prices. None of the extra costs ever found its way into our price structures. Would a refining segment of the industry, completely divorced from any marketing interests, have been willing to sacrifice profits to such an extent?

9.) When an integrated company is faced with an emergency, it can and frequently does alter its refinery yields to assure adequate supplies of individual products even though, at the time, economics would not favor the move. Partial divorcement would lessen this flexibility. Disintegration would eliminate it.

10.) The government is asking for divorcement of marketing, yet the government is always the first to turn to the integrated company when it wishes advice or cooperation from the industry in projecting any favored program. When any department of government wishes, it finds the integrated company a useful sounding board for a discussion of any of the industry's many phases. If there no longer were spokesmen for every level of the industry, it is quite conceivable that the government would embark on an ill-advised legislative course, with ever and ever-increasing controls foisted on the industry as a whole.

11.) Is it possible that the government has forgotten the value of the integrated company with its stake in every level of operation in the solution of the host of problems that arose in connection with military and civilian supply during World War II? Has the role of the integrated company in coordinating the immense job of planning and executing this war's petroleum program been ignored? Can any one show how divorcement could be anything but harmful to the war effort now or in the future?

It is strange that the government should wish to push the clock of distribution back to the dark ages of the Industrial Revolution when every separate manufacturing operation was conducted by a different individual or a different company. As late as 1910, there continued to be a multiplication of middlemen and I'm sure that many here can recall the agitation against the middleman and the long spreads that then existed between manufacturing and consumer prices. The gradual development of integration in all phases of industry that began about 1920 became an important—perhaps the most important—factor in the gradual reduction of distribution expenses.

Early in 1949, shortly after the introduction of the Gillette divorcement bills, jobber organizations began sounding out the sentiment of their membership and the great majority of the state jobber councils went on record as being opposed to the idea of divorcement. The basis of this attitude was undoubtediy a deep-seated dislike of unnecessary government intervention in the affairs of private business and a deep-seated mistrust of its motives in trying to do so.

It was recognized that discriminatory legislation, which appeared to favor one branch of the industry today, could and probably would be supplemented by additional legislation tomorrow that would favor none but the little men in Washington who thrive on big government. Finally, jobber organizations recognized the fundamental right of the American businessman to experiment with differing combinations of business functions in his drive toward greater efficiency and greater profits as one of the most important influences in the contribution of the American businessman toward making the American standard of living the highest that has ever been attained anywhere at any time.

Petroleum Industry in War

In World War II, 60 percent of the total tonnage represented by all men, munitions, and materials employed by the Allied forces was represented by petroleum products alone. And, in the event of another worldwide struggle, our dependence on petroleum would be even greater.

Our analysis of marketing divorcement leads us to believe that it is not in the interests of the American people in time of peace. In time of war, or in time when limited war is under way and general war threatened, the prosecution of socialistic experiments by economic theorists is offering aid and comfort to our enemies.

Our government cannot afford to indulge in political manipulation and socialistic and ideological experiments under today's conditions. They must be immediately and ruthlessly eliminated.

Anaconda heat exchanger tube advice is—

AUTHORITATIVE

Tube bundles for high pressure feed water heaters in central station power plant. Tube material: ANACONDA Cupro-Nickel. Coils fabricated by Carl Bobke, Coppersmith, Milwaukee, Wis. Feed water inside tubes, steam outside bled from plant turbines.

here's why—

For years we have conducted laboratory and field investigations of condenser and heat exchanger tube materials, structure, applications and performance.

The data files, built up during this long period, are exhaustive. We have dependable facts and figures on tube materials found practical in a wide variety of applications.

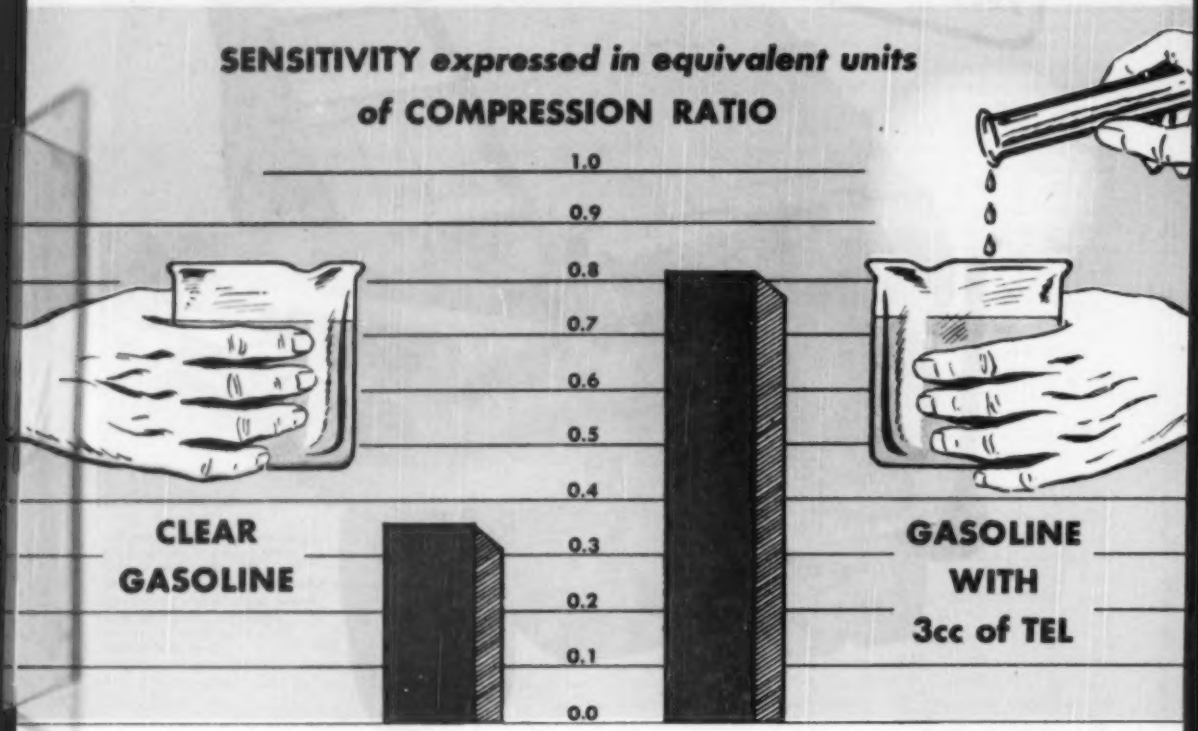
Backed by this definite, reliable information, Anaconda Condenser and Heat Exchanger Tube Engineers are confidently able to help you select tubes that will serve you best.

Let us undertake a study of your heat exchange problems at your convenience. There's no obligation, of course. The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

For efficient heat transfer ANACONDA® HEAT EXCHANGER TUBES

EXTRA "SENSITIVITY" OF LEADED GASOLINE

helps refiners meet requirements of modern engines



In the automobiles produced in the early 30's there was no particular advantage in using fuels whose Research ratings were substantially above their Motor ratings. However, designers of automotive engines have reduced the temperatures to which the fuel-air mixture is subjected in the intake manifold and cylinders and have made other changes which have increased the value of higher Research ratings.

Today, generally speaking, the higher the Research octane number of fuels having the same Motor Method rating, the better their performance on the road. The difference between these two methods of rating is often called "jump" and is one measure of fuel "sensitivity."

(Since "jump" is ordinarily expressed as octane units, the term "sensitivity" is used here to describe the same property of gasolines, expressed either as octane units or as equivalent units of compression ratio on an engine of good design.)

The effect of tetraethyllead on sensitivity

In tests of sixty-six regular and premium fuels the difference between the Research and Motor octane number was greater after the addition of 3.0 cc tetraethyllead in all except four of the fuels (Chart 1). The biggest improvement was 3.4 octane numbers; the average was 1.3.

While sensitivity is usually expressed in octane

EFFECT OF 3.0 CC TETRAETHYLLEAD PER GALLON ON "SENSITIVITY" OF COMMERCIAL GASOLINES

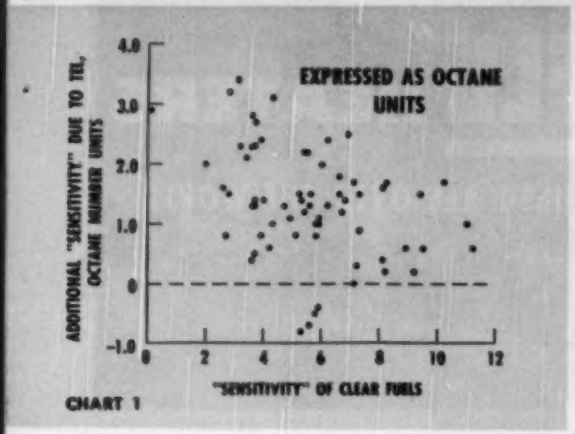


CHART 1

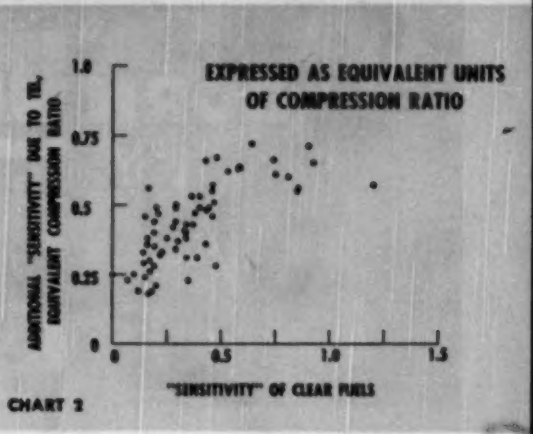


CHART 2

number units, a more realistic evaluation is obtained when it is expressed as equivalent units of compression ratio. This is true because of the non-linearity of the octane scale in terms of engine performance factors. Octane units get bigger and bigger toward the upper end of the scale.

Chart 2 shows that the additional sensitivity contributed by tetraethyllead (measured as equivalent units of compression ratio) is far greater than might be expected from the difference in sensitivity expressed in octane number units. Even the four fuels which have a negative improvement in sensitivity measured by octane units show a positive improvement expressed as equivalent units of compression ratio. In fact, on the average, the sensitivity of leaded fuels is more than twice the sensitivity of the clear fuels, expressed as equivalent units of compression ratio.

The greatest gain attributable to tetraethyllead is equivalent to 0.75 compression ratio; the smallest is 0.18 ratio; the average is 0.44 ratio. *In all the gasolines the sensitivity is greater with tetraethyllead than without it.*

Another important finding is shown in Chart 3—the higher the concentration of tetraethyllead, the greater the improvement in sensitivity expressed in terms of equivalent units of compression ratio.

An aid to meeting modern engine requirements

As automobile manufacturers have improved the design of engines by taking advantage of the sensitivity of motor fuels, any feasible method for improving fuel sensitivity without lowering the Motor Method rating has become of distinct advantage to the refiner. In this evolution, tetraethyllead has become increasingly valuable through its contribution to fuel sensitivity.

EFFECT OF TEL CONCENTRATION ON "SENSITIVITY" OF COMMERCIAL GASOLINES

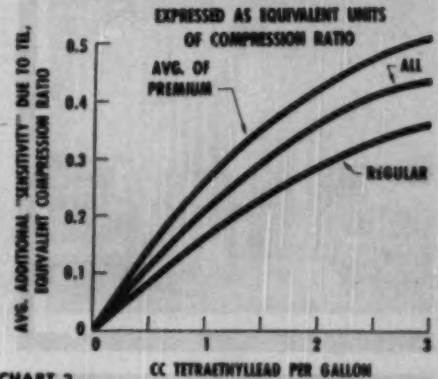
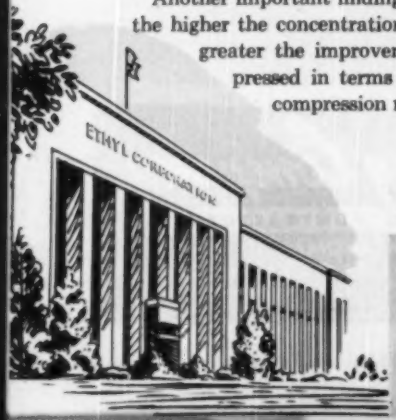


CHART 3



Over 400 specialists working full time on fuel and engine developments

ETHYL CORPORATION
RESEARCH LABORATORIES

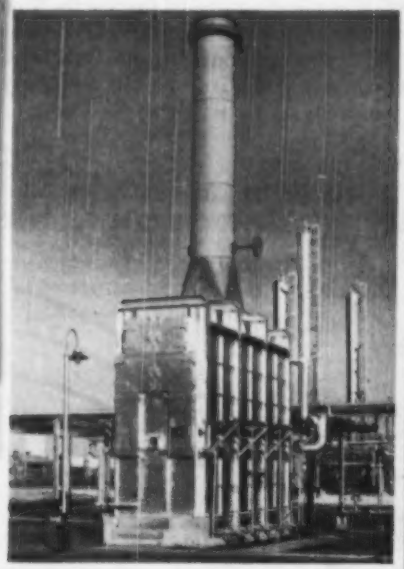
DETROIT, MICHIGAN
1600 West Eight Mile Road

SAN BERNARDINO, CALIFORNIA
2600 Cajon Road

BORN "UPFLO" HEATERS

ARE USED ALL OVER THE WORLD

A Born "UPFLO" Heater of the type shown here was recently installed for "SACOR" at Lisbon, Portugal by Born Engineering Company who supervised the construction and utilized local labor for erection.



BORN "UPFLO" HEATER FEATURES:

1. Develop higher efficiencies
2. Have lower construction cost
3. Have lower operating cost
4. Have negligible maintenance cost
5. Use less ground space
6. Greater safety

Before buying another heater call or write your nearest Born Engineering Representative and learn all of the facts about efficient heating.

BORN Engineering Company

ENGINEERS and CONTRACTORS

TULSA, OKLAHOMA

Representatives: LOS ANGELES, CALIF., C. R. Nantz & Co. — SHREVEPORT, LA., Bass Sales & Equipment Co. HOUSTON, TEXAS, Sales Engineering Co. of Houston, Inc. — NEW YORK, N. Y., Richard Merton

Canadian Associates: BRANDON, MANITOBA, Canadian Brown Steel Tank Co., Ltd.

PLANT COMPLETED—Opening of Humble Oil & Refining Company's new natural gasoline plant at Jourdanton, south of San Antonio (see accompanying picture), completed the company's $33 million gas conservation program as originally planned at the end of World War II.

Humble now is conserving about 85 percent of all the casinghead gas it produces from its oil wells. Its conservation program included 32 projects built since 1945. In all, Humble has invested about $42 million in facilities to handle 450 million cubic feet of casinghead gas daily.

The new Jourdanton plant, a conventional oil-absorption type unit, has a total capacity of 26 million cubic feet of gas daily.

THE next tabulation showing Refinery and Other Plant Construction will appear in the issue of January, 1951.

For NEWS ITEMS relating to many of the projects listed below, please turn to page 154.

REFINERY and Other PLANT CONSTRUCTION

Owners, operators and others are asked to help PETROLEUM REFINER keep this **QUARTERLY** list up to date by 1) sending in data on projects not listed, 2) furnishing details which may be missing from the current tabulation and, 3) reporting from time to time on the progress of these projects. Address Editor, PETROLEUM REFINER, Box 2608, Houston 1, Texas.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
*Aurora Gasoline Co.	Detroit, Mich.	Platforming Unit	4,500 bbls.		Under Constr.	May, 1951	U.O.P.	U.O.P.	U.O.P.
*California Refg. Co.	Perth Amboy, N. J.	New Refinery Units		$30 million	Under Constr.	1st Qtr., 1951			
Calif. Refg. Co.	Barber, N.J.	Crd. Cat. Crk., Reformer, Alkylation Crude Units Boiler Plants	25,000 bbls. 10,000 bbls. 5,000 bbls. 50,000 bbls. 300,000 lbs./hr.		Under Constr.	Jan., 1951	Houdry U.O.P. Kellogg	Houdry, Braun Braun Kellogg Braun Braun	Braun Braun Kellogg Braun Braun
Calif. Refg. Co.	Barber, N.J.	3 Gaso. Trtng., Lead Sulfide Sweetening Plt., Reagent Plt.			Contracted			Cat. Constr.	Cat. Constr.
E. I. Dupont de Nemours & Co., Inc.	Parkersburg, W. Va.	Tetrafluorethylene Resin Plt.			Completed				
*Esso Standard Oil Co.	Bayway, N.J.	2 Desalt. Units	45,000 each		Planned or Under Constr.	Feb., 1951			
Freeport Sulphur Co.	Westville, N.J.	Sulfur Recovery	40 tons		Under Constr.	1950			Girdler
Kendall Refg. Co.	Bradford, Pa.	Platforming Unit	1,500 bbls.		Contracted	Late 1950		U.O.P.	U.O.P.
*Louisville Refining Co.	Louisville, Ky.	Cat. Cracker	2,000 bbls.	$2 million	Under Constr.	July, 1951		U.O.P.	
Mathieson Hydrocarbon Chemical Corp.	Brandenburg, Ky.	Chemical Plt.		$17 million	Under Constr.	End 1951		Badger, Stone & Webster	Badger, Stone & Webster
*Mid-West Refineries, Inc.	Alma, Mich.	Platforming Unit	1,500 bbls.		Under Constr.	Early 1951	U.O.P.	U.O.P.	U.O.P.
*New York State Natural Gas Corp.	Boom Sta., Lawrenceville, Pa.	Nat'L-Gas Dehydration Plt.	200,000 mcf	$250,000	Contracted	Dec., 1950		Blaw-Knox	Staff
*Petro Corp.	Chicago, Ill.	Houdry Cat. Crk.	5,000 bbls.	$2 million	Completed				
The Pennzoil Co.	Rouseville, Pa.	Propane-Deresin, Resin-Fract.	1,730 bbls.		Designing	End 1950		Kellogg	Kellogg
*Sinclair Refining Co.	Marcus Hook, Pa.	LPG Unit	1,100 bbls.		Completed				
*Socony-Vacuum Oil Co.	Buffalo, N.Y.	Poly Plt.			Under Constr.	1951		Bechtel-Staff	Bechtel
*Socony-Vacuum	Buffalo, N.Y.	Expand. Gas Recov. Facilities			Under Constr.	1951		Bechtel-Staff	Bechtel
Socony-Vacuum	Buffalo, N.Y.	Houdry to TCC	15,000 bbls.		Under Constr.	Late Fall, 1950	Socony-Vacuum		
Socony-Vacuum	Brooklyn, N.Y.	Houdry to TCC	15,000 bbls.		Under Constr.	Late Fall, 1950	Socony-Vacuum	Foster Wheeler	Foster Wheeler
L. Sonneborn Sons	Petrolia, Pa.	Antipollution Acid Stripping Plt.		$450,000	Under Constr.	1st Half, 1951		Chemico, Knowles	Keen & Wise, Chemico
Tennessee Gas Transmission Co.	Greensburg, Ky.		600,000 mcf gas	$12 million	Under Constr.	Summer, 1951		Staff	Staff
*Union Oil Co.	Edmonds, Va.	Asphalt Refinery	65,000 tons		Under Constr.	June, 1951			Bechtel
United Refining Co.	Warren, Pa.	Lab. Steam Gen.	60,000 lbs./hr.			4th Qtr., 1950			Union Iron Wks.
MID-CONTINENT									
The Bell Oil and Gas Co.	Grandfield, Okla.	Platforming Unit	1,500 bbls.		Under Constr.	Fall, 1950		U.O.P.	
*Cities Service Oil Co. (Del.)	Ponca City, Okla.	Cat. Crk. & Cat. Poly, Gas Plt.	8,600 bbls.		Planning	Late, 1951		Kellogg	Kellogg
Cities Service, Del.	Cicero, Ill.	Compound Plt.	1,200 bbls.	$4 million	Completed				Sollitt
Consolidated Gas Utilities Corp.	Cement, Okla.	Compr. Sta.	40,000 mcf		Under Constr.	3rd Qtr., 1950		Dresser	Dresser U.O.P., Brown & Lite
*Continental Oil Co.	Ponca City, Okla.	Res. Lab. Bldg.		$2.3 million	Under Constr.	Fall 1950		Wigton-Abbott	Wigton-Abbott
Deep Rock Oil Corp.	Cushing, Okla.	Cat. Cracker, Topp., Res. Labs., Off. Bldg. Add., Ref. Aux. Units	5,000 bbls.		Completed			U.O.P.	J. & L. Constr.

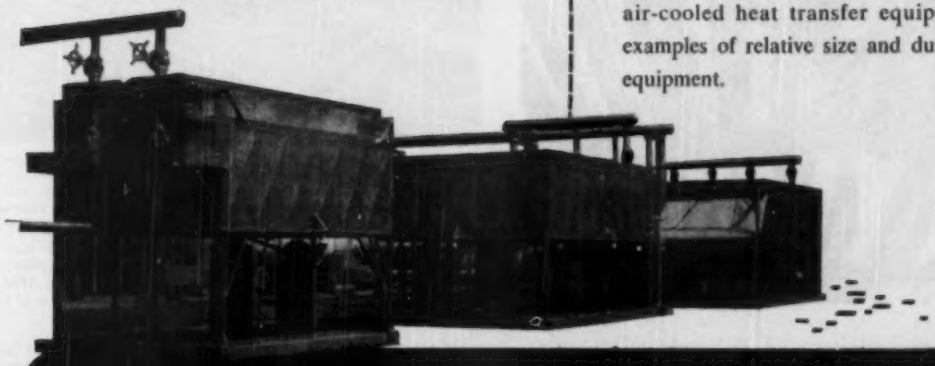
REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
*Deep Rock Oil Corp.	Cushing, Okla.	Crd. Topp. Unit Res. Lube Blending Plt., Storage Tnks., Boiler Plt. Expan. Cooling Towers	.....	.....	Completed	.....	.....	.....	.....
The Derby Oil Co.	Wichita, Kans.	Cat. Crk Change	.....	$2 million	Planning	.....	.....	.....	.....
Dewese Oil Co.	Weston, Ohio	Lube Filtering	250 bbls.	$15,000	Under Constr.	3rd Qtr., 1950	.....	Staff	Staff
*Dow Chemical	Midland, Mich.	2nd Hypvesorption Unit	.....	.....	Contracted	.....	Union Oil (Calif.)	Foster Wheeler	Foster Wheeler
Indiana Farm Bureau Cooperative Assn.	Mt. Vernon, Ind.	Fluid Cat. Cr.	4,000 bbls.	.....	Under Constr.	1951	.....	U.O.P.	Staff
Indiana Farm Bureau	Mt. Vernon, Ind.	Gas Concen.	3,500 bbls.	.....	Under Constr.	1951	.....	.....	U.O.P.
Indiana Farm Bureau	Mt. Vernon, Ind.	Vacuum Unit	300 bbls.	.....	Under Constr.	1951	.....	.....	U.O.P.
*Johnson Oil Refg. Co.	Cleveland, Okla.	Platforming	1,800 bbls.	.....	Designing	Jan. 1, 1951	.....	U.O.P.	U.O.P.
Midland Co-Op. Wholesale Co.	McPherson, Kans.	Expansion	†22,000 bbls.	$4 million	Planned	.....	.....	.....	.....
Mississippi River Fuel Co.	Fredericktown, Mo.	Comp. Sta.	4,000 hp.	.....	Under Constr.	3rd Qtr., 1950	.....	Ref. Maint.	Ref. Maint.
National Co-Op. Refinery Assn.	McPherson, Kans.	Polymerization, Fld Cat. Crk., Add tnkge, Util	†22,000 bbls.	$2 million	Under Constr.	.....	U.O.P.	Ref. Eng.	Ref. Eng
Oklahoma Refg. Co.	Seminole, Okla.	Refinery	200 bbls.	$40,000	.....	.....	.....	.....	.....
*Pan-Am. Southern Corp.	El Dorado, Ark.	Fluid Cat. Crk., Vap. rec. Unit	7,000 bbls.	.....	Under Constr.	March, 1951	.....	Foster Wheeler	Foster Wheeler
Pan-Am. Southern	El Dorado, Ark.	Delayed Coke Water Cooling Tower, Steam Gen. Boiler, Coke & Loading	9,300 bbls.	.....	Completed	.....	.....	Lummus	Lummus
*Peteo Corp.	Chicago, Ill.	Houdry Cat. Crk.	5,000 bbls.	.....	Under Constr.	Oct., 1950	.....	.....	.....
Peteo Corp.	Blue Island, Ill.	Houdry, Cat. Crk., LGP Recov.	5,000 bbls.	$400,000	Under Constr.	3rd Qtr., 1950	Houdry	Houdry	Clarke, Cat. Constr.
Petroleum Specialties, Inc.	Flat Rock, Mich.	Cat. Cracker	3,000 bbls.	$2 million	Planning	.....	.....	.....	.....
*The Pure Oil Co.	Crystal Lake, Ill.	Research Labs.	.....	.....	Completed	.....	.....	.....	.....
The Shallow Water Refining Co.	Shallow Water, Kans.	Poly Unit	60 bbls.	$100,000	Under Constr.	Nov. 1, 1950	U.O.P.	Koch	Staff
Shell Oil Co.	Elk City, field Okla.	Gas Extract Plt.	100,000 mcf gas	.....	Contracted	End 1950	.....	Ref. Maint.	Ref. Maint.
Shell Oil	Wood River, Ill.	Asph Load Fac.	.....	.....	Completed	.....	.....	.....	Fluor
*Socony-Vacuum Oil Co., Inc.	E. Chicago, Ind.	Houdry to TCC	†5,000 bbls.	.....	Under Constr.	1950	.....	.....	Braun
*Socony-Vacuum	E. Chicago, Ind.	Houdry Conv. to T.C.C.	.....	.....	Planning	.....	Socony-Vacuum	.....	.....
Socony-Vacuum	Augusta, Kans.	Houdry TCC	15,000 bbls.	.....	Under Constr	Jan., 1951	Socony-Vacuum	Fluor	Fluor
Socony-Vacuum	Trenton, Mich.	Houdry to TCC	15,000 bbls.	.....	Under Constr.	End 1950	Socony-Vacuum	Braun	Bechtel
*Standard Oil Co. (Ohio)	Cleveland, Ohio	Cat. Cracker	20,000 bbls.	.....	Under Constr.	1951	.....	Bechtel	Bechtel
*Standard (Ohio)	Lima, Ohio	Cat. Cracker, Crude Coker, Solvent Lube Plt., Central Shop, Lab., & Office Bldg.	75,000 gals	$30 million	Completed	.....	.....	.....	Lummus, Kellogg, Ferguson
*Standard (Ohio)	Cleveland, Ohio	Crd. Dist. Plt.	45,000 bbls.	$5½ million	Planning	Nov., 1951	.....	.....	McKee
Standard (Ohio)	Cleveland, Ohio	Houdry to TCC	18,000 bbls.	$4 million	Under Constr.	Dec., 1950	Socony-Vacuum	Bechtel	Bechtel
Standard (Ohio)	Lima, Ohio	Clay Contact	1,800 bbls.	$750,000	Completed	.....	.....	Lummus	Lummus
Standard (Ohio)	Lima, Ohio	Solvent Dewax.	2,500 bbls.	$4 million	Completed	.....	Texaco	Lummus	Lummus
*Stanolind Oil & Gas Co.	7 mi. W. Ulysses, Kans.	Inc. Cap. to Gaso Plt.	200,000 mcf	.....	Planning	.....	.....	.....	.....
The Texas Co.	Lawrenceville, Ill.	Expand Refinery	†20,000 bbls.	.....	Under Constr.	April, 1951	.....	Foster Wheeler Kellogg	Foster Wheeler, Kellogg
U.S. Dept. of Interior	Louisiana, Mo.	Demonstration oil-from-coal	80 bbls.	$4-$5 million	Completed	.....	.....	Koppers	Koppers
Vickers Petroleum	Potwin, Kans.	Desalting	6,000 bbls.	.....	Completed	.....	.....	.....	.....
SOUTHWEST									
Alba Refg. Co.	Alba, Texas	Asphalt Refining	2,000 bbls.	$150,000	Under Constr.	3rd Qtr., 1950	.....	.....	.....
*Arizona Interests	Florence, Ariz.	Refinery	15,000 bbls.	$25 million	Planning	1952	.....	Ebasco	.....
*Arkansas-Louisiana Gas Co.	Blanchard, La.	4,200 hp Compressor Sta.	65,400 mcf	.....	Under Constr.	Late 1950	.....	Staff	Delta
Barnsdall Oil Co., Op.	Scurry Co., Tex.	Nat. Gaso. Plt.	50,000 mcf gas	$6.5 million	Considering	Feb., 1951	.....	.....	.....
*Bay Petroleum Corp.	Chalmette, La.	Modernization Fluid Cat. Crk., Revamping UOP Thermal Cracking for Feed Preparation	6,000 bbls.	.....	Under Constr.	End 1951	U.O.P.	U.O.P.	Procon, Inc.
Carthage Hydrocol, Inc.	Brownsville, Texas	Hydrocol	87,000 mcf	.....	Under Constr.	Summer, 1951	Hydro-Res., Inc. Texaco	McKee, Hydro-Res., Inc.	McKee
*Continental Oil Corp.	Lake Charles, La.	Expansion, Cat. Crk., add'l equip. for High Octane Production	25,000 bbls.	$10½ million	Planning	Early 1952	.....	.....	To be awarded
Del Rey Petroleum Co.	Chesterville, Texas	Pressure Absorption Plt.	25,000 mcf	.....	Under Constr.	.....	.....	O. L. Olson	Ole Olson
The Dow Chemical Co.	Freeport, Texas	Chemicals, Expansion	.....	$30 million	Engineering	End 1951	.....	Staff	Tellepsen, Pritchard, Austin, Stone & Webster
Dow Chemical	Freeport, Texas	Ammonia Plt.	100 tons	$5 million	Planning	Late 1950	.....	.....	Austin
*El Paso Natural Gas	Scurry County, Texas	Compressor Sta.	2,640 H.P.	$800,000	Under Constr.	4th Qtr., 1950	.....	Staff	Staff
El Paso Natural Gas	Crane Co., Tex.	Compressor Sta.	4,400 hp.	$1.27 million	Completed	.....	.....	Staff	Staff
E. I. DuPont de Nemours & Co., Inc.	Victoria, Texas	Chemical Intermediate for Nylon	.....	.....	Design	Early 1951	.....	Staff	Staff
*Esso Standard	Baton Rouge, La.	Desalting Unit	55,000 bbls.	.....	Planned or Under Constr.	Feb., 1951	.....	.....	.....
Esso Standard Oil Co.	Baton Rouge, La.	Main Office, Cafeteria	.....	.....	Completed	July, 1950	.....	Bechtel & Murell, Staff	Staff, Harris
*Ethyl Corporation	Baton Rouge, La.	Pilot Plt. Bldg.	.....	.....	Under Constr.	Aug., 1950	.....	Staff	Pioneer
*Ethyl Corp.	Houston, Texas	Chemicals Mfg Plt.	100 mln. lbs./yr.	.....	Under Constr.	End 1951	.....	.....	.....

Continued on Page 75

Here are 15 TYPICAL APPLICATIONS for FIN-FAN AIR-COOLED Heat Exchanger Equipment

For many years, Fin-Fan Air-Cooled Heat Exchangers have proved their worth by giving reliable, economical service in many and varied applications. The Fluor Corporation, Ltd., and Griscom-Russell Company, pioneer-partners in the air-cooled heat transfer field, offer the following to show the large variety of practical applications for air-cooled heat transfer equipment and examples of relative size and duty of such equipment.



GAS COOLING	Natural Gas After-Cooler	13,920,000	80	46' x 25'
	Manufactured Gas Cooler	11,165,000	50	23' x 21'
	Natural Gas After-Cooler	3,400,000	15	11' x 21'
	Natural Gas Inter-Cooler	7,890,000	40	23' x 21'
VAPOR CONDENSING	Reflux Condenser	18,407,000	90	48' x 25'
	Primary Condenser	4,632,000	40	11' x 25'
	Still O.H. Condenser	4,875,000	34	16' x 21'
	Debutanizer Condenser	11,930,000	60	23' x 25'
	Still Reflux Condenser	39,110,000	60	46' x 25'
	Steam Condenser	87,300,000	300	138' x 31'
	Steam Condenser	2,880,000	10	10' x 6'
LIQUID COOLING	Vegetable Oil Cooler	628,000	15	6' x 17'
	Absorption Oil Cooler	14,915,000	100	32' x 17'
	Quenching Oil Cooler	1,665,000	50	23' x 25'
	Amine Solution Cooler	19,300,000	175	38' x 25'
	Stabilized Crude Cooler	125,100,000	700	315' x 25'
	Jacket Water	2,400,000	5.5	16' x 12'
	Jacket Water	28,800,000	100	70' x 24'

A new 8-page bulletin on Fluor-GR Fin-Fan Heat Exchangers is now being prepared. Write in and reserve your copy by post card or letter.

Why Fluor-GR Fin-Fans Lead The Field

The Fin-Fan Air-Cooled Heat Exchanger is unique in its development and manufacture. It is the result of the engineering skill of *two* companies, *each* long recognized as leaders in their respective fields. It combines Fluor's experience in the design, fabrication and field erection of air-moving systems with Griscom-Russell's experience in heat transfer.

Success is evident in repeat orders. Since 1941, hundreds of Fluor-GR Air-Cooled Heat Exchangers have been installed throughout the world . . . nearly 50% have been repeat orders!

FLUOR

BE SURE WITH FLUOR

ENGINEERS • CONSTRUCTORS • MANUFACTURERS

THE FLUOR CORPORATION, LTD., 2500 S. Atlantic Blvd., Los Angeles 22, Calif., *Offices in principal cities in the United States*
REPRESENTED IN THE STERLING AREAS BY: Head Wrightson Processes Ltd., Teesdale House, Baltic Street, London, E.C.1., England

This close-up clearly shows the ribs or corrugations which add strength to Childers Jacketing and also make it form more easily around lines. Aluminum strapping and seals are a quick, inexpensive way to attach the jacketing. They can be used without any special tools and take no special training for the installers.

Does long lasting aluminum cost too much for covering your insulated lines? Not when you specify this new type weatherproof jacketing. It has been specially developed to cost little more than ordinary temporary jacketing materials.

New Low-Cost Jacketing Cuts Maintenance on Insulated Lines

AT LAST an aluminum jacket has been "engineered" especially to protect outdoor lines in refineries and chemical plants. It is the first "permanent-type" jacketing that offers both low initial cost and low application cost.

After two years of tests and major installations at 431 outdoor locations in refineries, chemical plants, and power plants, the Childers Manufacturing Co. of Houston has rung up an impressive cost-cutting record with their Childers Aluminum Jacketing.

Secret behind this low cost is the thin aluminum sheet—.006" thick—which is the weather-protecting sheath of the jacketing. It is ribbed (as pictures show) for extra strength and to facilitate forming around the line. This aluminum has proved thick enough to resist weathering and usual abrasion, but costs much less than heavier aluminum sheets.

Easy application of this Childers Jacketing cuts labor bills drastically. It comes from the factory in easy-to-handle rolls that are four feet wide and either 100 feet or 200 feet long. It is light and flexible to handle as the men put it on the line. No roll forming required as with heavy, un-crimped material. It can be cut off and attached just the same as the old-fashioned tar-paper that was sometimes used for jacketing.

You can attach Childers Jacketing around your insulated lines by one of several easy methods. The use of aluminum strapping and seals is probably the best. Sheet metal screws or Minnesota Mining's No. 471 tape can also be used.

The Childers jacketing can be removed and re-used.

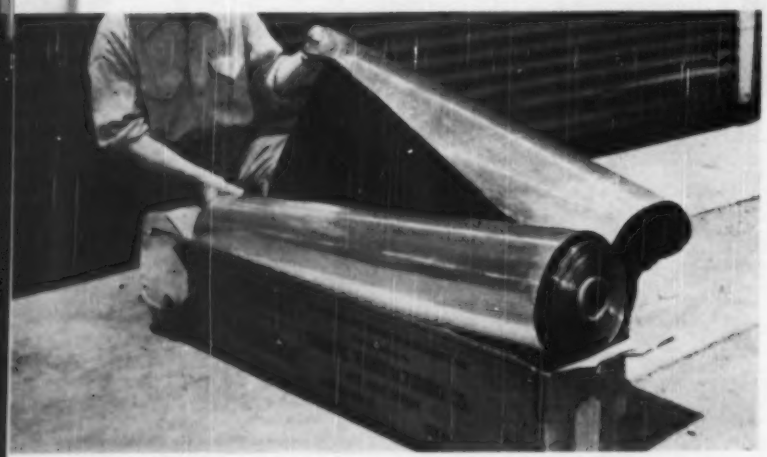
A moisture barrier is attached to the back of the jacketing to give positive protection for the aluminum when it is used with alkaline insulating materials.

No painting, no rust-proofing, little maintenance — that's the advantage of aluminum!

Hundreds of design engineers and maintenance engineers have agreed they save money for their firms and trouble for themselves by changing their jacketing specs to Childers 100%. That should make it worth your testing too—and a test roll costs only $36.00 for 400 sq. ft. (with moisture barrier attached—price for jacketing without mosture barrier much less). That's a good investment in any plant. (Advt.)

* * *

FOR FULL INFORMATION write Childers Manufacturing Co., Dept. PR-I, 625 Yale St., Houston 7, Tex., for complete literature. Childers has engineering representatives in principal cities to work with you on specific problems.



This is how Childers Aluminum Jacketing is shipped in easy-to-handle rolls. It is quite flexible, yet stands up under severe weathering.

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Fullerton Oil Co.	Snyder, Texas	Refrig. Nat. Gaso. Pln.	40,000 mcf		Under Constr.	Fall, 1950			Hudson
*Gulf Oil Corp.	Port Arthur, Texas	Fluid Cat. Crk.	60,000 bbls.	$8 million	Under Constr.	Sept., 1951			Kellogg
*J. M. Huber Corp.	Baytown, Texas	Car. Blk. Plt.		$1.5 million	Under Constr.				Stearns-Rogers
Humble O&R.	Baytown, Texas	Roof Replacing of Butyl Bldg.			Completed			Staff	Tellepsen
Humble O&R.	Baytown, Texas	Miscl. Facilities		$1 million	Projected				Knutson
Humble O&R.	Baytown, Texas	Research Bldg.			Completed			Voorhees-Walker Ferguson	Bellows
Humble O&R.	Baytown, Texas	Mech. Maint. Bldg.			Completed			Foster Wheeler	Foster Wheeler
*Humble O&R.	Baytown, Texas	3 stage Crude	48,000 bbls.			Mid., 1951			
Magnolia Pet.	Beaumont, Tex.	Thermofor Cat. Cracker	15,000 bbls.			1950			Lummus
Magnolia Pet Co.	Beaumont, Tex.	Two Houdry's to TCC	30,000 bbls.		Authorized	Late 1950			
Mathieson Chem. Co.	Pasadena, Texas	Fertilizer Plt.			Under Constr.	1950		Owner	
McMurrey Refining Co.	Tyler, Texas	Fluid Cat. Cracker, Gas-Conc., Feed Prep. & Cycle-Oil Crk.	5,000 bbls.		Under Constr.	Jan., 1951		U.O.P. and Ref. Eng.	Ref. Eng.
*Monsanto Chemical Co.	Texas City, Tex.	Acrylonitrile Mfg. Facil.; Plt. Expansion		$30 million	Planning				
North American Oil Consolidated & Ungren & Frazier	Bartlett Field, Jones County, Texas	Gaso. Plt., Gas Injection Facilities			Planning				
*Pan American Refining Corp.	Texas City, Tex.	Research Bldg.			Completed			Ferguson	Ferguson
*Phillips Chemical Co.	Borger, Texas	Carbon Black Plt.	80,000 tons/yr.		Planning	4th Qtr., 1951			
Phillips Petroleum Co.	Phillips, Texas	Cat. Cracker	20,000 bbls.		Under Constr.	July, 1951			Bruns
Pontiac Refining Co. & Chicago Corp.	Corpus Christi, Texas	Ref. Petro-chem. Plt.	5,000 bbls. gaso., 170,000 bbls. ethylene glycol, 3,000 lbs. ethylene	$15 million	Design, Planning	Mid., 1951			
*Premier Pet. Co.	Ft. Worth, Tex.	Platforming Unit	1,500 bbls.		Under Constr.	Feb., 1951	U.O.P.	U.O.P.	Hudson
The Pure Oil Co.	Dollarhide, Andrews Co., Tex	Nat. Gaso. Plt.	$6 million		Under Constr.	Fall, 1950			
*Shamrock Oil & Gas Corp.	McKee, Texas	Reconstruct Gaso. Ref. Treater		$80,000	Planning				
Shamrock Oil & Gas Co.	Sunray, Texas	Houdry Cat. Crk.	5,900 bb'ls		Under Constr.	Early 1951	Houdry		Cat. Constr. (Philadelphia)
*Sid Richardson Refining Co.	Texas City, Tex.	Refinery Alterations	30,000 bbls.		Under Constr.	Oct. 15, 1950		Staff	Staff
Standard Oil Co. of Texas	7 mi N. Snyder, Scurry Co., Tex.	Gaso. Absorp. Plt.	20,000 mcf	$1.5 million	Completed			Staff	Staff
Standard (Texas)	Cedar Point, Texas	Compressor Instln.			Completed			Staff	Pioneer
Stanolind O&G.	Brownsville, Tex.	Chemical Plt.	150 tons		Under Constr.	Fall, 1950		Badger	Badger
*Sunray Oil Corp. (Op.)	Scurry Co., Tex.	Gasoline Plt.	67,000 mcf gas		Contracted	July, 1951		Fluor	Fluor
Superior Oil Co.	Ramsey Field, Colo. Co., Tex.	Nat. Gaso. Plt.	50,000-70,000 mcf. gas	$1.5 million	Under Constr.	June 30, 1951		Brown & Root	Brown & Root
United Gas Pipe Line	Sterlington, La.	Dehydration	†25,000 mcf		Under Constr.				Staff
ROCKY MOUNTAIN									
Frontier Refining Co.	Cheyenne, Wyo.	2 Coke Crks.	3,500 bbls.	$725,000	Completed		U.O.P.	Ref. Eng.	Ref. Eng
New Mexico Asphalt and Refining Co.	Artesia, N.M.	Pkg. TCC Unit, Cat. Poly Unit	6,000 bbls. 300 bbls.		Contracted	Feb.-May, 1951	Socony-Vacuum Hydro Res.		Sweco
*Pyn Am Southern Corp.	El Dorado, Ark.	Fluid Cat. Crk., Vapor Unit			Under Constr.	1951			Sweco
Pan-Am Southern	El Dorado, Ark.	Cat. Crk., Vap. Recov.	9,000 bbls.	$2.7 million	Contracted	April, 1951			Foster Wheeler
Pan-Am. Southern	El Dorado, Ark.	Coking Unit	9,300 bbls.		Completed			Lummus	Foster Wheeler
Salt Lake Refining Co.	Salt Lake City	Cat. Cracking	25,000 bbls.	$10 million	Authorized	Jan., 1951	Houdry	Bechtel-Houdry	Bechtel
*Salt Lake Refining	Salt Lake City, Utah	Cat Cracking Unit	10,000 bbls.		Under Constr.	Late 1950		Bechtel, Houdry	Bechtel
*Salt Lake Refining	Salt Lake City, Utah	Vac. Flasher	9,500 bbls.		Under Constr.	Late 1950		Bechtel	Bechtel
Sioux Oil Co.	Newcastle, Wyo.	Thermal Crk.	1,200 bbls.	$300,000	Completed		U.O.P.	Koch	Staff
Sioux Oil Co.	Newcastle, Wyo.	Cat. Poly.	60 bbls.	$100,000	Completed		U.O.P.	Koch	Staff
*Standard Oil Co. (N. Dakota)	Grand Forks, N. Dakota.	Refinery	2,000-2,500 bbls.		Planning				
WEST COAST									
Continental Oil Co.	Ventura, Calif.	Rev. to Gaso. Plt.	23,000 mcf		Completed			Ref. Maint.	K. & A.
Hancock Oil Co.	Long Beach,	Ethylene Glycol	60,000 lbs.		Considering			Ref. Maint.	Ref. Maint.
Stancal Asphalt & Bitumuls Co.	Point Wells, Wash.	Asphalt Refg.			Under Constr.			Badger	Badger
Standard Oil (Calif.).	Richmond, Calif.	Vac. Tower TCC	55,000 bbls.		Approved	May, 1951	Houdry	Staff	Bechtel
		to Houdry	45,000 bbls.		Engineering	May, 1951			
*Standard Oil Co. of Calif.	Richmond, Calif.	Vac. Flasher	55,000 bbls.		Contracted	May, 1951			Kellogg
*Sunray Oil Corp.	Santa Maria, Calif.	Modern. of Ref.			Completed				
Union Oil Co. of Calif	Brea Olinda, Cal.	Research Plt.		$5 million	Projected	July, 1951		Austin, Field and Fry	Walker
*Union Oil Co. of Calif.	Edmonds, Wash.	Asphalt Refining	65,000 tons Annually		Under Constr.	June, 1951			Bechtel
FOREIGN									
Canada									
*British American Oil, Ltd.	Edmonton, Alberta	Refinery Offsite Facilities			Contracted	June 1, 1951		Staff	Barnes
*British-American	Moose Jaw, Sask.	Cat. Crk., Coker Thermal Crk., Cat. Poly., Utilities	10,000 bbls.		Under Constr.	Fall, 1951		U.O.P.	Pro. Eng.
*Canadian Oil Refineries	Fromsfield, Ont.	Refinery	20,000 bbls.	$18 million	Planning	April, 1952		Stone & Webster	Stone & Webster
British-American	Edmonton, Alberta	Refinery	5,500 bbls.		Under Constr.	Early, 1951		Can. Kellogg	Can. Kellogg
Excelsior Refs., Ltd.	Lloydminster, Alberta	Inc. Capacity	3,000 bbls.		Under Constr.	1950			

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	License	Engineering	Contractor
Excelsior Refg., Ltd.	Lloydminster	Inc. Capacity	1,500 bbls.		Design	1950			
*Imperial Oil, Ltd.	Regina, Saskatchewan	Desalting Unit	16,000 bbls.		Planned	Early 1951	Howe-Baker	Staff	Staff
Imperial Oil	Winnipeg	New Refinery	10,000 bbls.	$10 million	Under Constr.	May, 1951		Canadian Kellogg	Canadian Kellogg
*Imperial Oil	Edmonton, Alta.	Desalting Unit	22,000 bbls.		Planned	Early 1951	Petreco	Staff	Staff
McColl Frontenac Oil Co., Ltd.	Edmonton, Alta.	Crd. Processing Cat. Crk.	5,500 bbls.	$10 million	Contracted	1951		Foster Wheeler	Foster Wheeler
Panther Oil and Grease Co.	Leaside, Toronto, Ontario	Grease and Compounding			Projected				
Shell Oil Co. of Canadian, Ltd.	Montreal East, Quebec	Fluid Cat. Crk., Vac. Flash Gas Recov., Poly. Treat.	35,000 bbls.		Under Constr.	Oct., 1950		Staff	Fluor, Ltd., McKee
Supreme Refineries, Ltd.	Hanna, AB.	Nat. Gaso. Pl.	1,000 mcf	$100,000	Under Constr.	Fall, 1950		Staff	Staff
Supreme Refineries	Ogden, AB.	Refinery	1,000 bbls.	$100,000	Under Constr.	Fall, 1950		Staff	Staff
Latin America									
Administration Nacional Combustible Alcohol y Portland	Montevideo, Uruguay	Lube, Asphalt Units	7,500 bbls.		Under Constr.	Fall, 1950		Foster Wheeler	Staff
Conselho Nacional do Petroleo	Matarize, Bahia, Brazil	Thermal Cracking Refinery	2,500 bbls.	$5 million	Under Constr.	Dec., 1950		Kellogg	Kellogg, Staff
Conselho Nacional do Petroleo	Cubatao Sao Paulo, Brazil	Therm. Crk. Ref.	45,000 bbls.		Designing			Hydrocarbon	Fives-Lille & Schneider, Staff
Conselho Nacional do Petroleo	Matarize, Bahia, Brazil	Ref. Exps.	2,500 bbls.	$3.5 million	Planning	Dec., 1950			
*The Corporacion de Fomento de la Produccion	Concon, Valparaiso, Chile	Refinery	14,000 bbls.	$9 million	Planning	1953			
Creole Pet. Corp.	El Roble Field, Venezuela	Repressuring			Planning				
*Creole Pet. Corp.	Amuay Bay, Venezuela	Vac. Dist.	35,000 bbls.		Under Constr.	Late 1950		Foster Wheeler	Foster Wheeler
Ipiranga S.A. Cia Brasileira de Petroleos	Rio Grande, Brazil	Therm. Crk. Ref.	2,000 bbls.		Authorized	1952	Foster Wheeler		
*Petroleos Mexicanos	Tamaulipas, Ciudad Madero, Mex.	Enlarge Refinery Capacity	47,250 bbls.		Planning				
*Petroleos Mexicanos	Tamaulipas, Arbol Grande Pet., Mex.	Enlarge Refinery	16,500 bbls.		Planning				
*Petroleos Mexicanos	Mata Redonda, Vera Cruz, Mex.	Improvements	9,000 bbls.		Planning				
*Petroleos Mexicanos	Poza Rica, Mex.	Improvements to Skimming Plant	3,100 bbls.		Planning				
Petroleos Mexicanos	Poza Rica, Mex.	Gas Purification, Pressure Maint.		$13 million	Under Constr.	Dec., 1950		McKee	McKee
Petroleos Mexicanos	Salamanca, Mex.	Crd., Gasoil, Crk.	25,000 bbls.	$12 million	Completed		U.O.P.	McKee	McKee
Petroleos Mexicanos	Reynosa, Mex.	Refinery	4,000 bbls.	$1 million	Under Constr.	Jan., 1951		Staff	Staff
Phillips Oil Co.	San Roque Fld., Anzategui, Venezuela	Refinery, Wax Pl.	2 mln. lbs. wax/year		Planning	1952			
Puerto Rican Oil Refining Co.	Near Ponce, Puerto Rico	Refinery	25,000 bbls.	$20 million	Projected	1st Qtr., 1951	Undetermined	Parsons, Brinckerhoff, Hall and Macdonald	
Refinaria de Petroleos do Distrito Federal S.A.	Rio de Janeiro, D. F. Brazil	Therm. Crk.	10,000 bbls.		Authorized				Fives, Lille, Schneider, Staff Foster Wheeler
Refinaria e Exploracao de Petroleo Uniao S.A.	Capuava, Sao Paulo, Brazil	Therm. Crk. Ref.	20,000 bbls.		Authorized			P.A. Hydro. Res.	Czech, Fact. Metal Work Mech. Constr.
Richmond Exploration Co.	Bajo Grande, Venezuela	New Refinery	35,000 bbls.		Referred				
Shell Caribbean Pet. Co.	La Paz, Venezuela	Gas Plant	90 tons		Under Constr.	End Oct., 1950			
Shell Caribbean Pet. Co.	Mara, Ven.	Gas Plant	90 tons		Projected	June, 1951			
*Shell Co. of Venezuela	Cardon, Ven.	Comprehensive Refg.	38,000 bbls.		Under Constr.	Early 1952			
Venezuelan Pet. Co.	Puerto la Cruz, Venezuela	Refinery	35,000 bbls.		Completed			Suare	Suare
Yacimientos Petroliferos Fiscales	Buenos Aires, Argentina	New Refinery	28,000 bbls.	$54 million	Design	1951		Kellogg	Kellogg
YPF	La Plata, Argentina	Crude Topping, Gaso. Treating	50,000 bbls.	$2.8 million	Under Constr.	Fall, 1950		Houdry Process Cat. Constr.	Cat. Constr.
YPF Bolivianos	Cochabamba, Bolivia	Topping & Reforming Units	5,000 bbls.		Under Constr.	3rd Qtr., 1950		Foster Wheeler	Foster Wheeler
Europe and Africa									
Anglo-American Oil	Fawley, Eng.	Refinery	110,000 bbls.	$150 million	Under Constr.	Jan., 1952		Foster Wheeler	Foster Wheeler
*Anglo-American	Fawley, Eng.	Poly Unit			Design			Badger	Badger
Anglo-American	Fawley, Eng.	SO_2 Extraction	13,000 bbls.		Under Constr.			Foster Wheeler	Foster Wheeler
Anglo-American	Fawley, Eng.	Fluid Cat. Crk.	1 million gals.						
Anglo-Iranian Oil	Isle of Grain, Eng.	Cent. Refg. Unit	60,000 bbls.	$120 million	Planning	1952			
Anglo-Transvaal Consolidated Investment Co.	Vall River, Union of South Africa	Synthetic Gasoline and Diesel Oil Plt.		$50-60 million	Contracted			Hydro. Res.	
*Aquila, S.A.	Trieste, Italy	Prop. Deasph., Furf. Sol. Ref. MEK Dewax. Contact Filtr. Dist. & Blending Plt.	100 tons 95 U1 Lubes & Bright Stocks 8 tons all Paraffin Waxes	$7.9 million	Under Constr.	March, 1951	Juik, Texaco	Badger	Badger
*Aquila, S.A.	Trieste, Italy	Reformer & Cu Cs Splitter	3,000 bbls.		Completed		U.O.P.	U.O.P.	U.O.P.
Aquila, S.A.	Trieste, Italy	Lube Oil Ref.	800 bbls.	$7.9 million	Design	Mar., 1951	Juik, Texaco	Badger	Badger
Azienda Generale Italiane Petroli	Rome, Italy	Add to Plant	24,000 bbls.		Projected	Late 1951			
Azienda Generale Italiane Petroli	Palermo, Italy	Marine Fuel Plt.	7,500 bbls.						
Bataafsche Pet. Mij	Pernis, Holland	Expansion	77,500 bbls.		Under Constr.	2nd Half, 1951			
British Petroleum Chem.	Grangemouth, Scotland	Petrochem			Under Constr.	Dec., 1950		Stone & Webster	Stone & Webster
Cabot Carbon, Ltd. (Godfrey L. Cabot, Inc.)	Ellesmere Port, Eng.	Carbon Black Plt.	50,000 lbs./yr.		Under Constr.	1950		Simon-Carves, Ltd.	Simon-Carves, Ltd.
Shell-Berre	Berre, France	Expansion	65,000 bbls.	$31.6 million	Under Constr.	Early, 1952			
Shell-Berre	Petit-Couronne	Teepel Plt.	25,000 tons/yr.		Under Constr.	1st Qtr., 1951			

Continued on Page 79

ALCOA

Alcoa Heat Exchanger News

PUBLISHED BY ALUMINUM COMPANY OF AMERICA

ALCLAD TUBES... a bargain in corrosion resistance

If you are troubled by the corrosion effects of sulfur compounds, oxygen, or carbon dioxide in cooling waters, alclad tubes offer a long-lasting solution.

Alclad tubes have given long service life in many fresh, brackish, and salt waters where high industrial contamination exists. Alclad tubes withstand waters having a wide pH range.

Coating Resists Corrosion

The zinc-aluminum alloy layer galvanically resists corrosion of the base aluminum alloy structure of the tube—acts like a "built-in" anode. Corrosion is confined within the integral cladding layer. Even when large areas of the alclad coating have been destroyed by electrolysis, the rest of the coating still continues to protect the exposed alloy core. Alclad tubes have withstood such corrosive attack for more than ten years, without failure.

Alclad Costs Little

The remarkable thing about alclad tubes are their low price. Foot for foot, metal for metal, they cost less than any other tubes except bare aluminum. Twenty per cent less than ordinary steel. Forty-seven per cent less than Admiralty. A sixth as much as stainless steel.

We'd like to tell you more about the savings possible with alclad tubes—amounting to thousands of dollars every month in many plants. Write to us. ALUMINUM COMPANY OF AMERICA, 1494K Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA OFFERS NEW BOOK This new, 24-page book will answer many of your questions about Alcoa tubes. It covers fabrication techniques, alloy selection, chemical and petroleum applications. It describes tube cleaning, inhibitors, cathodic protection. It contains complete information on fluid flow and heat transfer. There are formulas, tables, and specification data. Write for your free copy today. ALUMINUM COMPANY OF AMERICA, 1494K Gulf Building, Pittsburgh 19, Pa.

THESE APPLICATIONS ARE NATURALS FOR ALCLAD TUBES:

Petroleum

- Condensing of hydrocarbon fractions such as naphtha, gasoline, and gas oil
- Vapor-recovery condensers
- Lube-oil coolers
- Natural-gas compressor aftercoolers
- TCC overhead condensers
- Recompressor aftercoolers
- Hydrogen-sulfide gas coolers
- MEA-solution coolers and exchangers
- Furfural condensers and exchangers
- MEK service
- Propane chilling
- Wax sweaters
- Depropanizer overhead condensers

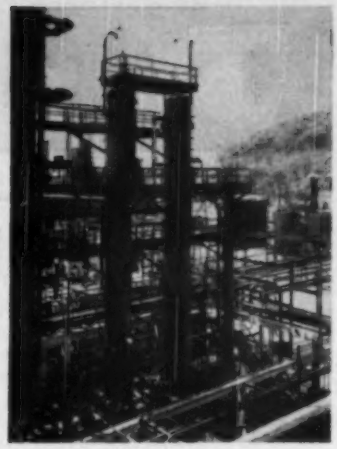
Chemical

- Butanol
- Ethanol
- Ethylene Glycol
- Glycerin
- Hydroabietyl
- Isopropanol
- Methanol
- Phenol
- Propylene Glycol
- Acetaldehyde
- Formaldehyde
- Acetic Acid
- Butyric Acid
- Stearic, Palmitic, Oleic Acids
- Recinoleic Acid
- Acetanilide
- Ammonia and Ammonium Hydroxide
- Hydrogen Cyanide
- Nitric Acid (concentrated)
- Pyridine
- Hydrogen Sulfide
- Benzene
- Benzol
- Dichlorobenzene
- Gasoline
- Gelatin
- Hydrogen Peroxide
- Methyl Ethyl Ketone
- Turpentine

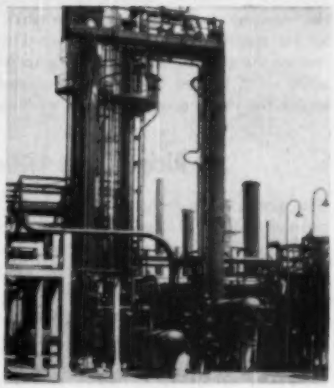
These listings cannot cover the many hundreds of other chemicals with which aluminum tubes can be used

Chemical Plant...Texas

Works speak louder than words



Refinery...Ohio



Refinery... Illinois

Chemical Plant... Arkansas

They all use **Girdler GIRBOTOL Plants** to remove acid gases

YOU CAN COUNT on Girdler's wide experience in building GIRBOTOL plants to keep right on growing. For the GIRBOTOL process is the *most economical method known* for removing acid gases, such as hydrogen sulphide and carbon dioxide from gas mixtures. More and more companies are proving that to their own satisfaction with operating data from their GIRBOTOL plants.

The GIRBOTOL Process is the *accepted* process for purifying gaseous refinery hydrocarbons. And more than a score of GIRBOTOL plants are being used to remove hydrogen sulphide from liquid hydrocarbons such as butane, propane, polyfeed stocks, straight-run naphthas and gasoline.

You'll find the GIRBOTOL Process not only the lowest cost method of hydrocarbon purification, but it may also be a source of valuable by-product hydrogen sulphide, used to produce elemental sulphur.

You can obtain technical help from Girdler on problems involving the manufacture, purification, separation, or utilization of industrial gases. Call or write us now.

GAS PROCESSES DIVISION

THE GIRDLER CORPORATION

LOUISVILLE 1, KENTUCKY

DISTRICT OFFICES:
150 Broadway, New York City 7
2612 Russ Bldg., San Francisco 4
311 Tulsa Bldg., Tulsa 3

DESIGNERS, ENGINEERS AND CONSTRUCTORS

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Shell-Berre	Petit Couronne, France	Lube Unit			Planned				
*Cie Francaise de Raffinage	La Mede, France	Cat. Crk., Gas Recov. System	11,500 bbls.	$10 million	Authorized	1953			
*Cie Francaise de Raffinage	Gonfreville, France	Gas Recov. System							
Cie. Francaise de Raffinage	Gonfreville, France	Therm. Reform., Prop. Deasp., Furfl. Trtng.	4,750 bbls.		Under Constr.	1952	Texaco & Jutk	Kellogg	Leml
Cie. Francaise de Raffinage	Gonfreville, France	Lube Unit	2,500 bbls.		Design	1951	Texaco	Kellogg-Lummus	
Cie. Francaise de Raffinage	Gonfreville, France	Distillation Unit	20,000 bbls.		Completed			Foster Wheeler	Foster Wheeler
Cie. Francaise de Raffinage	Provence, France	Topping Unit	20,000 bbls.		Completed			Foster Wheeler	Foster Wheeler
Cia Espanola de Petroleos, S.A.	Sta. Cruz de Tenerife, Canary Islands	Propane-Butane Fractionating	304 bbls.	$100,000	Under Constr.	Late 1950		U.O.P.	U.O.P.
C.E.P.S.A.	Canary Islands	Propane-Deasc.	700 bbls.	$300,000	Under Constr.	Late 1950	Standard Oil	Foster Wheeler	Foster Wheeler
Condor, S.P.A. Per l Industriale Pet. Chemica	Rho, Italy	New Refinery	1.5 mln. tons/yr.		Under Constr.				
Danish Government	Denmark	Refinery	21,000 bbls.		Planned				
*Deutsche-Amerikaniche Petro-Gesellschaft (Esso)	Hamburg-Harburg, Germany	Cracking Plt.	8,843 bbls.			4th Qtr., 1953			
Egyptian Government	Cairo, Egypt	Crude Plt.						Lummus	Lummus
*Egyptian Government	Suez, Egypt	Int. Refn. Cap.	30,000 bbls.	$2,500,000	Planning				Lummus
*Esso Standard Refg.	Antwerp, Belg.	New Refinery Incl. Crker.	25,000 bbls.			July, 1953			
*Gewerkschaft Erdoel-Raffinerie England	Near Lingen, Germany	Refinery	11,535 bbls.	$8,670,000		4th Qtr., 1952			
Industrie Chimiche Italiane Petroli	Mantau, Italy	Crude	4,500 bbls.						
Industria Nazionale Petroli e Trasforma ziche	Mosm Carrara, Italy	Refinery	40,000 bbls.			Late 1951			
Industria Petrolifera e Chimica	Milan, Italy	Gasoline Fuel Oil Plt.	20,000 bbls.					Dr. Calogero Ingiagio	
*Industria Raffinazione Olii Minerali (IROM)	Porto Marghera, Italy	Crk. equipment	4,000 bbls.	$2 million	Planning				
Imperial Chemical Industries, Ltd.	Wilton, Yorkshire, England	Petroleum Cracking Unit			Under Constr.	End 1950		Kellogg	Kellogg
L'Alliance Petrolina.	Antwerp, Belg.	Refinery	21,000 bbls.		Planned				
Manchester Oil Refinery, Ltd.	Partington, England	New Lube Refinery	30,000 bbls.		Projected				
Monsanto Chemical Co.	Britain	Add Polystyrene			Under Constr.	July, 1951		Staff	Staff
National Oil Refineries	Llandarcy, Wales	Furf. Ref. Sol. Dewax, Wax Fractn.	1,200 bbls.	$36 million	Designing	Early 1953	Texaco	Badger	Badger
National Oil Refineries	Llandarcy, Wales	SO_2 Solvent Extraction	3,000 bbls.		Contracted	Early 1951		H.W.P.	H.W.P.
Pechelbronn, S.A. E. M.	Merkwiller, France	Capacity Increase	1,550 bbls.		Authorized	1950			
*Permolio, S.P.A., Raffinerie Italiane Olii Minerali	Genoa, Italy	Cat. Cracker	1,630 bbls.		Planning	4th Qtr., 1951		Foster Wheeler	Foster Wheeler
*Permolio	Rome, Italy	Cat. Cracker	1,630 bbls.		Planning	4th Qtr., 1951		Foster Wheeler	Foster Wheeler
Petrochemicals, Ltd.	Partington, England	Petrochemicals	2,000 bbls.	$16 million	Under Constr.	4th Qtr., 1950	Petrocarbon	Petrocarbon	Petrocarbon
Philblack, Ltd.	Avonmouth, England	Carbon Blk. Plt.	137,000 bbls.	$5 million	Contracted	Fall, 1950	Phillips	H.W.P.	H.W.P.
Ref. de Pet. de Escom. S.A.	Escombreras, Spain	Add Refinery	30,000 bbls.	$20 million	Under Constr.	Mid., 1952		Foster Wheeler McKee	Foster Wheeler
*Raffinerie de Petrole de la Gironde (Caltex)	Bordeaux, France	Increase Tank Capacity	14,000 bbls.	$8 million	Completed				
Raff. Belge de Petroleos, S.A.	Antwerp, Belg.	Topping Unit	8,000 bbls.	$1,000,000	Contracted	Sept., 1951		H.W.P.	Chaurobel
Raffinerie Belge	Antwerp, Belg.	Atmos., Vac. Distill.	7,000 bbls.	$1.5 million	Planning	June, 1951			
Raffinerie Belge	Antwerp, Belg.	Therm. Crk., Reform., Gas Plant	7,000 bbls.	$2 million	Completed			Barnes	Barnes
Raffineries Francaises de Petrole de l'Atlantique	St. Nazaire, France	Consolidate Refineries	7,100 bbls.	$9.6 million				Separator-Noble	
Raffinerie Siciliane Olii Minerali, Sp.A.	Augusta, Sicily	Crude Refinery	10,000 bbls.		Under Constr.	Fall, 1950	U.O.P.	U.O.P., Delta, Staff, Separator-Noble	Staff
*Refineria de Petroleos de Escombreras, SA., (REPESA)	Cartagena, Spain	Atmos. Dist., Therm. Reformer, Cat. Poly., Lube Plt.	30,000 bbls.		Planned				
*REPESA	Cartagena, Spain	Lube Plt.			Projected				
Scottish Oils, Ltd.	Grangemouth, Scotland	Stage I: 1 Pipe Still Distill., Steam Boil & Power Plt.	1.5 mln. tons per yr. 20,000 kw.		Under Constr.	End 1950		Kellogg	Kellogg
Scottish Oils	Grangemouth, Scotland	Stage II: Cat. Crk., Vac. Distill., Cat. Poly Plt., & Trting Plt.			Planned	Mid., 1952			
Scottish Oils, Ltd.	Grangemouth, Scotland	Buoyancy Foundations			Under Constr.	End 1950		Rendel Palmer and Tritton	
Shell Chemical Mfg. Co., Ltd.	Thornton, Eng.	Teepol Plant Extension	75,000 tons per year		Under Constr.	Fall, 1950			
Shell Refining & Marketing Co., Ltd.	Stanlow, Eng.	Comprehensive Refining	60,000 bbls.		Under Constr.	Early 1952			
Shell Refining & Marketing Co., Ltd.	Shell Haven, England	Comprehensive Refining	40,000 bbls.	$34 million	Under Constr.	Early 1952			
Societe Generale Des Huiles de Petrole	Dunkirk, France	Crude Reform.	33,000 bbls.	$38,105,000	Under Constr.	Mid., 1951	Lummus, Kellogg	Lummus, Kellogg	Lummus, Kellogg
Societe Generale	Dunkirk, France	Furl. Ref. Sol. Dewax., Wax Fractn.	2,400 bbls.		Under Constr.	Mid., 1951	Texaco	Lummus	Lummus
Societe Industrial Belge des Petroles	Antwerp, Belg.	Crd. Crk. Ref.	20,000 bbls.		Under Constr.	Mid., 1951		Kellogg	Kellogg

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Societe Raffinazione Oli Minerali (IROM)	Porto Marghera, Italy	Atmospheric & Vac. Distill., Acid Treat., Contact Filtration for Lube Oils, Electric Gen. Unit, Load Facilities	11,600 bbls.	$6.4 million	Contracted	.....	.....	H.W.P.	H.W.P.
Societe per Azioni Raffineria Padana Oli Minerali	San Martino di Trecate, Italy	Refinery	13,000 bbls.	$15 million	Under Constr.	Fall, 1952	.....	Badger	Badger
*Socony-Vacuum Francaise	Frontignan, France	T.C.C. Unit	.....	.....	Planning	.....	Socony-Vacuum	.....	.....
Socony-Vacuum Francaise	Notre Dame de Gravenchon	MEK Unit	1,000 bbls.	.....	Under Constr.	Fall, 1950	Texaco	Lummus	Staff
Socony-Vacuum Francaise	Notre Dame de Gravenchon	Propane Deasphalting	1,100 bbls.	.....	Completed	.....	Juik	Lummus	Staff
Socony-Vacuum Francaise	Notre Dame de Gravenchon	Grease and Compounding	900 lbs.	.....	Under Constr.	Winter, 1950	.....	Staff	Staff
Socony-Vacuum Italiana, S.p.A.	Naples, Italy	Visbreaker	.....	.....	.....	Fall, 1950	.....	Staff	Staff
Socony-Vacuum Italiana, S.p.A.	Naples, Italy	Topping Unit	15,000 bbls.	.....	Under Constr.	Fall, 1950	.....	Staff	Staff
Stand Aziends Gen. Indro. Comb. (Stanic)	Leghorn, Italy	Ref. Expan.	13,000 bbls.	.....	.....	End 1953	.....	.....	.....
Stanic	Bari, Italy	Add Capacity	12,000 bbls.	.....	.....	.....	.....	.....	.....
Standard Francaise des Petroles	Port Jerome, France	Dewaxing Plant	1,200 bbls.	$6.4 million	Design	End 1951	.....	S.O.D.	Foster Wheeler
Standard Francaise des Petroles	Port Jerome, France	Desasphalting Plant	1,800 bbls.	.....	Design	End 1951	.....	S.O.D.	.....
*Standard Francaise des Petroles	Port Jerome, France	Cat. Crk.	10,000 bbls.	$10 million	Authorized	March, 1953	.....	.....	.....
Standard Oil Co., (N.J.)	Belgium	Dist. Crack	33,000 bbls.	.....	Planned	Early 1952	.....	.....	.....
Trent Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4.8 million	Plans approved	.....	.....	.....	.....
Union Petrol Refinery, Ltd.	Johannesburg, Union of South Africa	New Refinery	.....	$20 million	Projected	.....	.....	.....	.....
*Vacuum Oil Co., Ltd.	London, Eng.	Oil Refinery	6.3 mln. bbls./yr.	$28 million	Planning	.....	.....	.....	.....
Vacuum Oil Co.	Coryton, Eng.	Lube Refinery	17,000 bbls.	$20 million	Under Constr.	Sept., 1952	.....	.....	.....
Near East									
Anglo-Iranian Oil	Abadan, Iran	Gas Plant	25,000 mcf	$2 million	Under Constr.	1950	.....	Badger	Badger
Anglo-Iranian	Adadan, Iran	Cat. Cracker	30,000 bbls.	.....	Under Constr.	1951	.....	Foster Wheeler	Foster Wheeler
Anglo-Iranian	Adadan, Iran	Solvent Dewax.	700 bbls.	.....	Under Constr.	4th Qtr., 1950	Texaco	Badger	Badger
Anglo-Iranian	Abadan, Iran	Gas Recov., Stab.	22,000 mcf	.....	Under Constr.	Mar., 1951	.....	Badger	Badger
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Crude Oil Stabilizer	300,000 bbls.	$4.8 million	Under Constr.	Dec., 1950	.....	Staff and Fluor	Flour, Middle East, S.A.
Arabian American	Ras Tanura, S.A.	Asphalt Plant	500 bbls.	$1.25 million	Under Constr.	1950	.....	Staff, Bechtel	Staff
Bahrein Pet. Co., Ltd.	Bahrein Island	Crd. Still Util.	55,000 bbls.	$9.1 million	Under Constr.	Fall, 1950	.....	Lummus, Bechtel	Int. Bechtel, Inc.
Consolidated Ref., Ltd.	Haifa, Palestine	Crude Plant	80,000 bbls.	.....	Planned	Late, 1951	.....	Badger	Badger
Consolidated Ref., Ltd.	Haifa, Palestine	Gen. Facilities	.....	.....	Under Design	.....	.....	Badger	.....
Consolidated Ref., Ltd.	Haifa, Palestine	Lube Plant	2,500 bbls.	.....	Designing	.....	Texaco, Juik	Lummus, Kellogg	Lummus, Kellogg
*Kuwait Oil Co., Ltd	Ahmadi, Persian Gulf, Kuwait	Refinery	25,000 bbls.	.....	Completed	.....	.....	Badger	Badger
Far East									
Bataafsche Pet. Mij. (Shell)	Balikpapan, Borneo, East Indies	Expansion	50,000 bbls.	.....	Under Constr.	Mid., 1951	.....	.....	.....
Bataafsche Pet. Mij.	Pladjoe, Sumatra	Rehad. to Comprehensive Refg.	71,000 bbls.	.....	Under Constr.	Early 1952	.....	.....	.....
Burmah Oil Co., Ltd.	Syrinm, Burma	Furf. Sol. Dewax., Wax Mfg.	1,000 bbls.	$600,000	Designing	.....	Texaco	Badger	.....
Burmah Oil Co.	Syrinm, Burma	Thermafor Clay Revivification	66 tons	$150,000	Engineered	1950	Max Miller, Socony-Vacuum	Max Miller	.....
*Nederlandsche Raffinadery van Olie Production	Haarlem	Lube Oil Refing	.....	.....	Under Constr.	.....	.....	Separator-Noble	.....
*Nippon Oil Co.	Japan	Lube Oil Refining	.....	.....	Under Constr.	.....	.....	Separator-Noble	.....
Pacific Refineries, Ltd.	Honolulu, Hawaii	Butane, Asph., Gas Oil, Lt. Fretns. Refy.	3,000 bbls.	$1.5 million	Completed	.....	.....	Fish Eng.	Fish Eng
*Pacific Refiners	Honolulu, Hawaii	Benzol Plt.	.....	.....	Under Constr.	Dec., 1950	.....	Fish Eng.	Fish Eng.
Ton Nenryo Kogyo, Ltd.	Wakayama, Japan	Cracking	3,500 bbls.	.....	Designing	Fall, 1950	.....	.....	Staff
Oceania									
Australian Shell Oil Co.	Geelong, Victoria, Australia	New Refinery	.....	$4.8 million	Under Constr.	Late 1951	.....	.....	.....
Australian Shell Oil Co.	Geelong, Victoria, Australia	Bitumen and Luboil Plant	.....	.....	Projected	.....	.....	.....	.....
Australian Shell Oil Co.	Geelong, Victoria, Australia	Asphalt, Lube Sol. Extct Plt.	.....	.....	.....	.....	.....	.....	.....

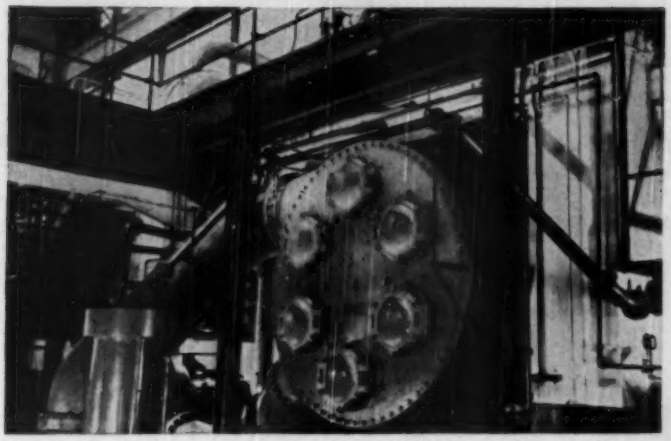
* First appearance in tabulation. † Added capacity.

NOTE: Austin—Austin Co. Badger—E. B. Badger & Sons. Barnes—W. M. Barnes & Co. Bechtel—Bechtel Corp. Bellows—W. S. Bellows Co. Blaw-Knox—Blaw-Knox Construction Co. Bowden—W. H. Bowden. Braun—C. F. Braun Co. Brown Eng.—Brown Engineering Co. Brown & Lite—Brown & Lite Co. Brown & Root—Brown & Root Construction Co. Cas. Kellogg—Canadian Kellogg Co. Cat. Constr.—Catalytic Construction Co. Chemico—Chemico' Construction Co. C.B.&I.—Chicago Bridge & Iron Works Co. Clarke—Clarke Construction Co. Constr. Service—Construction Service Co. Delta—Delta Engineering Corp. Dresser—Dresser Engineering Corp. E.&A.—Ehrhart & Arthur, Inc. Ferguson—H. K. Ferguson. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corp. Foster Wheeler—Foster Wheeler Corp. Gaso. Plant—Gasoline Plant Construction Co. General American—General American Transportation Co. Girdler—The Girdler Corp. Graff—Graff Engineering & Equipment Co. Graver—Graver Construction Co., Inc. Grebe & Doremus—Grebe & Doremus Process Co. Hammond—Hammond Iron Works. Harris—John W. Harris Associate, Inc. Houdry—Houdry Corp. Hudson—Hudson Engineering Corp. H.W.P.—Head Wrightson Process, Ltd. Hydro Res.—Hydrocarbon Research, Inc. Ind. Eng.—Industrial Engineers, Inc. J.&L. Constr.—Construction Division, Jones & Laughlin Supply Co. Kellogg—M. W. Kellogg Co. Koch—Koch Engineering Co. Koppers—Koppers Co., Inc. Knowles—Morris Knowles & Co. Knutson—Knutson Construction Co. Leonard—Leonard Construction Co. Lummus—The Lummus Co. Mahoney—Mahoney Contracting Co. Mason—Mason Brothers Construction Co. Mathews—Mathews Conveyor Co. McKee—Arthur G. McKee Co. Max. Miller—Max B. Miller & Co. Michael-Poling—Michael-Poling Construction Co., Inc. Montgomery—J. M. Montgomery & Co. P. A. Hydro Res.—Pan American Hydrocarbon Research, Inc. Parsons—The Ralph M. Parsons Co. Perco—Division Phillips Petroleum Co. Pet. Eng.—Petroleum Engineering, Inc. Petroco—Petroleum Rectifying Co. Pioneer—Pioneer Industrial Co. Pritchard—J. H. Pritchard Co. Pro. Eng.—Process Engineers, Inc. Process Constr.—Process Construction Co. Ref. Eng.—Refinery Engineering Co. Ref. Maint.—Refinery Maintenance Co., Inc. Rust Eng.—Rust Engineering Co. Rust Pro.—Rust Process Design Co. Schneider—Schneider & Cie. Snare—Frederick Snare Corp. Sollitt—Sumner S. Sollitt Co. S.O.D.—Standard Oil Development Co. State Eng.—State Engineering Co. Stearns-Roger—Stearns-Roger Manufacturing Co. Stone & Webster—Stone & Webster Construction Co. Telleperco—Telleperco Construction Co. Texaco—Texaco Development Co. U.O.P.—Universal Oil Products Co. Utah—Utah Construction Co. Voorhees, Walker, Foley & Smith. Walker—P. J. Walker Co. Waleo—Waleo Engineering. West—F. S. West Construction Co. White—J. H. White Corp. Eng. Wigton-Abbott Corp. Wigton-Abbott Corp. Wohlfeld—Wohlfeld Construction Co. Equally owned California-Texas Corp. and Socony-Vacuum Oil Co., Inc.

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared by Bridgeport Brass Company "Bridgeport" *Headquarters for BRASS, BRONZE, and COPPER*



The best tubes possible are needed in a power station condenser to meet the heavy demands made during peak production times. Reduced efficiency and breakdowns are costly during troubled times.

Importance of Selecting Tubes for Long Service Vital Factor

Heavy military and civilian demands for condenser and heat exchanger tubes and piping are taxing the capacity of the mills.

In the future, an increased armament program and shortages of raw materials may possibly lead to mandatory rather than the voluntary form of allocation.

Expansion in the power, refining and chemical fields as well as in other processing industries will also make itself felt in reducing the amount of tubing available for short-term delivery. Engineers would therefore do well to take the long-term viewpoint when selecting alloys.

Study Life, Not Profit

Many engineers have been satisfied to go along with certain tube alloys knowing that there were better alloys on the market but reluctant to increase costs.

With the future indefinite, it would be far better to carry on experimental work with other alloys to determine the alloy best suited to carry them through a long period of heavy armament, if not war, with a minimum of replacement.

One power concern operating two plants has found through study that at one station only aluminum brass will give anywhere near satisfactory service. At the second plant, this alloy has proved its value but Admiralty is still used.

With the knowledge that deliveries of aluminum and high-copper alloys may be curtailed through priorities and dwindling supplies of raw materials, this concern ordered aluminum brass for both plants as their equipment so that tubes may be interchangeable.

Duplex Should Be Studied

In many processing fields, Duplex Tubing (one metal inside and another outside to combat dual corrosion problems) has been overlooked due to the price differential despite the longer service this tubing might give. The heat conductivity of Duplex Tubing is often higher than the ferrous tubing which it replaces. By using Duplex Tubing best suited for the individual job, longer life can often be obtained. At the same time, the increased efficiency of Duplex Tubing will enable higher production at a time when equipment and facilities in all fields will be taxed. Duplex Tubing Technical Bulletin #1950 is available on request.

Shortages Felt

During the last war, about the only alloy available without a high government priority was Admiralty tubing (70% copper, 29% zinc, 1% tin).

Shortages of nickel affected the supply of corrosion-resistant cupro nickel tubing, which was also in great demand by the government for naval vessels. The high copper content of aluminum brass and bronze as well as the shortage of aluminum curtailed the supply of these alloys.

Admiralty is a good alloy for hundreds of salt water applications but in cases involving high water velocities trouble from impingement corrosion may occur.

Laboratory Help Available

Bridgeport's corrosion laboratory has conducted many years of research into the corrosion problem. This information has been greatly augmented by the experiences of plant engineers and operators. For help in selecting alloys for heat exchangers and processing equipment, write to the nearest sales office or contact Bridgeport directly. Also available is "The Condenser Tube Manual" which covers the normal corrosion problems encountered by operating engineers as well as various types of alloys to meet varying demands.

BRIDGEPORT BRASS

BRIDGEPORT BRASS COMPANY, BRIDGEPORT 2, CONN. • ESTABLISHED 1865

Mills at Bridgeport, Connecticut, and Indianapolis, Indiana • In Canada: Noranda Copper and Brass Limited, Montreal

WHY maintenance men breathe easier...

DYNALOGS* have

No slidewire • No Balancing Motor • No Batteries to standardize

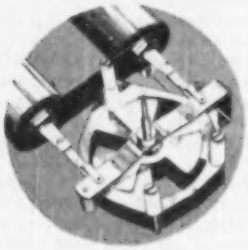
PRACTICALLY NO MAINTENANCE

With Dynalog Recorders and Controllers, maintenance men are freed from hazards of sticking electrical contacts and worn slidewires . . . freed from routine lubrication and cleaning of balancing motors, periodic standardizing and replacement of batteries. No wonder maintenance men breathe easier!

The simplicity of Dynalog design is one reason for its unequalled freedom from maintenance. In the entire balancing mechanism there are only four moving parts (none moving faster than the pen). It's free from the gears, cables, etc. used in conventional bridge-type instruments . . . the result of advanced engineering from concept to construction.

Freedom from maintenance is only one of many important advantages of Dynalog Instruments. They offer . . . *speed* that's full scale to new balance in as little as one second . . . *sensitivity*, one ten-thousandth of scale . . . *accuracy*, ¼ of 1% of scale. Available for measurement and control of temperature (with resistance bulbs or thermocouples), humidity, pressure, flow, force, pH, conductivity, etc. Get the complete story in Bulletin 427-1. Write **The Foxboro Company, 74 Neponset Ave., Foxboro, Mass., U.S.A.**

*Reg. U. S. Pat. Off.



The heart of Dynalog superiority

It's a simple variable capacitor! Taking the place of the conventional slidewire, this important component gives Dynalog Instruments absolutely STEPLESS continuous balancing. It gives you an instrument of extreme accuracy and stability, with a sturdiness that withstands the most severe industrial conditions.

FOXBORO DYNALOG*

Reg. U. S. Pat. Off.

The electronic potentiometer that has NO SLIDEWIRE

PETROLEUM
REFINER
OCTOBER, 1950
Volume 29 No. 10

Storage Tanks for Light Products—Propane, LPG, and Butane, at the Duback, La., Plant of Southwest Gas Producing Company, Inc.

A System of Process Calculations For Light Hydrocarbons

Part I

A. J. L. HUTCHINSON
Fish Engineering Company, Houston

ENGINEERS IN OPERATING plants and designers of new units spend much of their time in the calculation of process equipment and schemes. Setting up a processing system is a lengthy computation job. Each equipment item must be evaluated and the over-all results of the proposed process confirmed by calculation. Much trial-and-error work is necessary. Each process detail or operating alternate can be accepted or rejected only after calculations that are often extensive and tedious.

This is the first article of a series devoted to the simplification and standardization of calculation methods for light hydrocarbon processing plants. The author has developed a system which uses printed computation forms to expedite this work. An orderly procedure is achieved and any tendency toward waste motion sharply reduced.

In this and later articles the principles of process design calculations will be treated in some detail. The use of these printed calculation sheets will be demonstrated by the solution of actual problems in plant design and equipment evaluation. While it is certain that such organization can not replace process know-how and experience, it is equally certain that the intelligent use of these methods can greatly expedite the work of even the most experienced process men.

THE kinetic theory gives the basis for easy visualization of what takes place in gases and the equilibrium conditions that exist between gas, vapors, and liquids. So before going into the methods of calculation governing these equilibrium conditions, a short review of some of the basic assumptions of the kinetic theory will be given.

The considerations of the kinetic theory which follow, are brief and are not intended in any way to cover all the points involved. There are numerous standard books on kinetic theory that cover the subject fully that can be used for further clarification and extension of the ideas presented here.

In gases it is assumed that the volume is occupied by a large number of rapidly-moving particles which have perfect elasticity. These particles are in random motion. As a result of this random motion these particles, or molecules, will strike one another and the boundary walls of the containing vessels. Some of these collisions will be normal to the path of the molecules and some will be glancing blows. As these particles have perfect elasticity there is no heat change when they strike one another or when they strike the walls of the containing vessel, as the heat of the collision is reconverted to kinetic energy on rebound. This is just another way of saying that there is no energy loss or velocity loss on impact and rebound.

Another basic assumption of the kinetic theory is that the mean velocity of the molecules of any given gas is solely a function of temperature. As the temperature increases the mean velocity of the molecules increases and conversely if the temperature falls, the velocity of the molecules decreases and only becomes zero at absolute zero temperature. In speaking of the velocity of the molecules it is not assumed that all the molecules have the same velocity; some are traveling at high speeds, others at any instant of time may be stationary. No molecule can be stationary for any appreciable length of time, as it will be hit by another molecule. After such a collision the total energy of the two molecules will be that of the moving molecule. In gases at normal temperatures and pressures the volume surrounding the molecules is exceedingly large with respect to the volume of the molecules themselves, and for relatively large decreases in volume due to pressure or temperature the volume surrounding the molecules still remains large

with respect to the volume of the molecules themselves.

Assume some volume as represented in Figure 1. Likewise also assume that end wall *A* is a movable piston. In the total volume represented by Figure 1 the actual volume of the molecules is such a small volume with respect to the total volume, that the volume of the molecules can be neglected. Suppose now that wall *A* is moved to position indicated at *A'* at a constant temperature the volume occupied by the molecules themselves is still small with respect to the total volume. The pressure that any gas exerts against any restraining wall is due to the bombardment and rebound of molecules against that wall. Due to the perfect elasticity of the molecules they lose no energy on this rebound and, therefore, no heat is gained or lost due to this bombardment. From this it can be easily seen that the pressure is produced by the number of bombardments of the wall per unit time.

Referring again to Figure 1 — with the gas at some given pressure occupying the total volume — the number of bombardments of a unit area of the wall is fixed and the pressure will remain constant at a given temperature.

If wall *A* is moved to position shown by *A'* which it is assumed reduces the volume to one-half, it is seen that with the same number of molecules crowded into this reduced volume, the number of bombardments of the walls per unit area per unit time will be doubled.

As the pressure is a direct function of the number of bombardments per unit time, this means that the pressure will be doubled by reducing the volume of the gas to one-half.

This law correlating pressure and volume was first advanced by Boyle and bears his name. This law states that at a given temperature the pressure varies inversely with the volume. Stated in mathematical form this becomes:

$$PV = P_1V_1$$

where P and V are the initial conditions of the gas and P_1 and V_1 are the final conditions.

Another way to increase the pressure of a given volume of gas would be to increase the mean velocity of the molecules which in turn would increase the number and intensity of the impacts of the gas molecules against the restraining wall. From what was said above with respect to the effect of temperature on the velocity of the gas molecules, it can be readily seen that an increase of temperature by increasing the mean velocity of the molecules would increase the frequency and intensity of these bombardments.

Our temperature scale is arbitrarily selected so that the force of the bombardments of the gas molecules is directly proportional to the absolute temperature. As the temperature of the gas is decreased the velocity of the molecules decreases and finally becomes zero at a temperature of —460° F. This temperature of —460° F. is known as Absolute Zero. Absolute temperatures on the Fahrenheit scale are known as degrees Rankine. Degrees Rankine are equal to degrees Fahrenheit plus 460. The pressure of gas varies directly with the absolute temperature. This law was first advanced by Charles and bears his name. Stated in mathematical form where volume is constant this law becomes

$$PT_1 = P_1T$$

where P and T are the initial conditions of the gas and P_1 and T_1 are final conditions of the gas.

It follows from Boyle's law that this can also be stated where pressure is constant:

$$V_1T = T_1V$$

These two laws can be combined into one equation correlating pressure, temperature and volume. The combination of these laws gives us the equation

$$PV/T = P_1V_1/T_1$$

In practically all work involving solely physical relationships of gas and liquids, the primary interest is in the relative number of molecules in each phase and the total number of molecules in the system.

Avogadro stated that in a given volume under the same conditions of temperature and pressure all gases have the same number of molecules. This law holds very closely at low pressures and normal temperature.

On the basis of Avogadro's law it is seen that the relative density of any two gases would be in the ratio of their molecular weights. The molecular weight of any substance either gas, liquid or solid is the sum of the atomic weights of the elements in their proportions as stated in their chemical formula.

TABLE 1

Atomic Weight	Molecular Weight
O = 16	O_2 = 32
He = 4	He = 4
H = 1	H_2 = 2
N = 14	N_2 = 28

It will be noted Table 1 that the atomic weight of some of the gases is the same as the molecular weight of the gas, and in some, atomic weight and molecular weight are different. When working with pure gases it must be known whether atomic weight and molecular weight are equal or whether the molecular weights are some multiple of the atomic weights. This can be found in any handbook or chemical textbook. In gases encountered in petroleum work, molecular weight as stated above will be the sum of the atomic weights of the individual elements comprising the molecules. The atomic weight of carbon is 12 and as given above the atomic weight of hydrogen is 1. The above atomic weights are stated in round numbers and the use of the round numbers is usually accurate enough for engineering calculations. From the above the molecular weight of methane, the simplest hydrocarbon gas whose formula is CH_4, would be calculated as follows:

$$\begin{aligned} C \times 12 &= 12 \\ 4H \times 1 &= 4 \\ &\text{—} \\ &16 \end{aligned}$$

For the next member of the series, ethane, for which the formula is C_2H_6, the molecular weight would be calculated as follows:

$$\begin{aligned} 2C \times 12 &= 24 \\ 6H \times 1 &= 6 \\ &\text{—} \\ &30 \end{aligned}$$

From Avogadro's law the same volume of both these gases under the same conditions of temperature and pressure would contain the same number of molecules. Avogadro's law states that the same number of molecules of all gas under the same conditions of temperature and pressure occupy the same volume. As the molecular weights represent the weight of a definite number of molecules it follows that 16 pounds of methane will occupy the same volume as 30 pounds of ethane or 2 pounds of hydrogen or the molecular weight of any gas expressed in

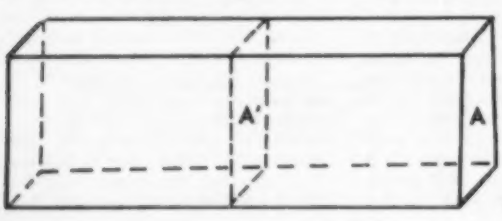


Figure 1

pounds at the same temperature and pressure.

The volume corresponding to the weight of gas expressed in pounds equal to its molecular weight is known as the pound molecular volume which we will call the mol. It has been determined that this volume is equal to 379 cubic feet measured at one atmosphere of pressure and 60° F.

Referring to Table 1, 379 cubic feet at one atmosphere of pressure and 60° F. of each of the gases will have the weight in pounds equal to the mol weights given. Air is a mixture of oxygen, nitrogen with small amounts of the noble gases (helium, argon, krypton, xenon) together with small amounts of hydrogen and carbon dioxide. The mean molecular weight of air is 28.96. The relative weight of any gas with respect to air is its mol weight divided by 28.96, the mol weight of air. This ratio is normally called the specific gravity of the gas with reference to air.

There are two methods in use for designating the specific gravity of a gas. One is its specific gravity with respect to air; the other is its specific gravity with respect to hydrogen. As the molecular weight of hydrogen is two, the specific gravity with respect to hydrogen is obviously one-half the mol weight.

In practically all engineering work the specific gravity of a gas is expressed as its specific gravity with reference to air as 1. In engineering work a gas under a pressure of one atmosphere and at a temperature of 60° F. is said to be under "standard conditions."

The "standard atmosphere" is the pressure of the atmosphere at sea level at a latitude of 45° and is 14.65 psi.

The "standard temperature" is 60° F., or 520 degrees Rankine.

Starting with the perfect gas law $PV/T = P_1V_1/T_1$ which can be rearranged into the form

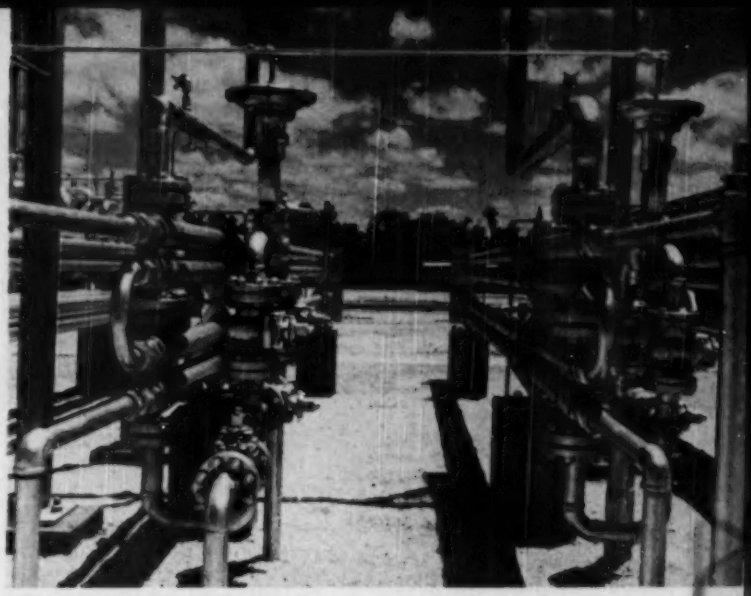
$$PV = P_1V_1/T_1 \times T$$

We have on the right side of the equation

$$P_1V_1/T_1$$

This term we can throw into a constant by assuming that P_1, V_1, T_1 are for one mol of gas at standard conditions. At standard conditions P is equal to 14.65; V = 379; T = 520, so that P_1V_1/T_1 will equal 10.7. The evaluation of P_1V_1/T_1 in the units in which the problem is to be worked gives us the numerical value of the universal gas constant *R*.

This constant *R* is the same for all gases and must not be confused with the gas constant often given in engineering handbooks which is *R* divided by mol weight of the gas. This *R* divided by mol weight of the gas is really the constant for one pound of a specific gas and, therefore, varies with each gas.



Product After-Coolers at the Dubach plant.

From Avogadro's law, all gases under the same conditions of temperature and pressure contain the same number of molecules. A general equation that will fit any number of mols of any gas will be

$$PV = NRT$$

where N is the number of mols of gas under consideration.

Referring again to Figure 1 suppose that *A'* constitutes a diaphragm separating the volume into two equal phases. Assume that on the left-hand side of this diaphragm there is some gas under standard conditions—on the right-hand side of the diaphragm a perfect vacuum. Assume that this diaphragm is ruptured and the gas then fills the whole volume, assuming that a constant temperature has been maintained, the pressure in this container would be one-half of an atmosphere. Assume that the gas, which is designated as gas *A* is again confined on the left-hand side of the diaphragm *A'*, and that on the right-hand side of the diaphragm there is a different gas *B*, both these gases under standard conditions—again rupture the diaphragm permitting the two gases to mix thoroughly with one another. It is obvious that the pressure within the system will not have changed at a constant temperature, that now the two gases occupy in a mixed state the total volume that they occupied previously segregated.

From our first example it was shown that gas *A* when expanded to the full volume only exerted a pressure of one-half atmosphere, similarly gas *B* when expanded to the full volume would only exert a pressure equal to one-half an atmosphere. However, the two gases together exert one atmosphere of pressure. Therefore, in this container each gas is acting as far as pressure goes as if it alone occupied the total volume. The pressure that each one of these gases exerts alone is known as its partial pressure. It makes no difference how many gases are present, each gas will exert a pressure in the container equal to the pressure that it would exert if it were present alone. The sum of all the pressures of all the gases is equal to the total pressure in the container.

The relative number of molecules of each gas in the mixture is called its mol fraction and is equal to the number of molecules of any gas divided by the total number of molecules in the system. In the example of gas *A* and gas *B* it is readily seen that the mol fraction of each gas when mixed is equal to .5 and that the pressure exerted by each gas is one-half atmosphere. This gives us a basis for our general law which was first proposed by Dalton and bears his name. Dalton's law states that the partial pressure of any gas is directly proportional to its mol fraction multiplied by the total pressure on the system. Stated in mathematical form:

$$P.P. = \text{mol fraction} \times \text{total pressure.}$$

This concept of independence of

action of each constituent in a mixture of gases is fundamental and the basis on which all equilibrium calculations between liquids and vapors is based, when no chemical reaction takes place.

In the discussion so far we have been dealing solely with what are known as "perfect gases." None of the known gases follow absolutely the laws stated above. Some gases that are normally encountered deviate widely from these laws, others under normal ranges of operation only show slight deviations. A perfect gas in reality is a hypothetical gas that will accurately obey the simple laws stated.

In the treatment of the perfect gas laws two factors have been entirely ignored: 1) the actual volume occupied by the molecules themselves and 2) the attractive or gravitational forces between the molecules.

These attractive forces between the molecules and the actual volumes of the molecules at low pressures are usually insufficient to be considered, but at high pressures and low temperatures they become quite appreciable.

There have been a number of equations proposed to take care of these factors and the best known is that proposed by van der Waal.

Van der Waal's reasoning was approximately as follows: The effective volume through which a gas can be compressed would be the difference between the total volume and the volume occupied by the molecules themselves. He stated then that the volume through which the gas could be compressed was $V - b$, b being the actual volume of the molecules. The pressure exerted on the gas would be the external pressure plus the attraction between the molecules themselves. He assumed that the attraction between the molecules themselves would vary inversely as the square of the total volume. His correction factor to pressure became therefore a/V^2. This term must be added to the external pressure so the total actual pressure on the gas would be $P + a/V^2$. Substituting these values in the gas equation $PV = NRT$, gives us the well known van der Waal equation of state

$$(P + a/V^2)(V - b) = NRT.$$

This equation holds fairly well over a wide range for most gases. The constants a and b must be determined experimentally for each gas. This limits the use of this equation to gases for which the a and b constants are known.

When heat is put into a gas to raise the temperature the velocity of the molecules is increased. If the gas is free to expand when the temperature is raised the gas will remain at a constant pressure. If the gas is confined in a definite volume, the increase in the temperature will increase the pressure. If what happens under these two conditions is considered, it will be seen that different amounts of heat are required to raise the temperature of a given amount of gas under the two conditions outlined above. In general it can be said that the heat introduced into the gas will be utilized to increase the velocity of the molecules and also to do external work.

With this in mind we write a general equation for specific heat as follows:

$$\text{Specific heat} = \Delta E + \int PdV$$

(This equation is for unit weight of gas through a unit temperature change.)

In this equation ΔE represents the amount of energy required to change the velocity of the molecules and may be defined as the change of internal energy of the gas. The $\int PdV$ is the energy that is absorbed to expand the gas from its initial volume to the final volume. This equation is the expression for specific heat at constant pressure.

If the gas is heated at constant volume the $\int PdV$ is zero as dV is zero. So the equation for specific heat at constant volume reduces to

$$\text{Specific Heat} = \Delta E \quad (V = \text{constant})$$

It is obvious from these equations that the specific heat at constant pressure is greater than the specific heat at constant volume and that the ratio of specific heats (N) is

$$N = \frac{\Delta E + \int PdV}{\Delta E} = 1 + \frac{\int PdV}{\Delta E}$$

The heat that goes into changing the internal energy of the molecules is used up in several ways. Part of the heat goes directly into changing the velocity of the molecules, part of the heat goes into rotational energy of the molecules, and part of the heat energy goes into vibrational energy within the molecules themselves. The majority of the heat introduced into most gases goes into increasing the velocity of the molecules. The energy that goes into the vibrational energy within the molecule is the energy that causes cracking of our hydrocarbon molecules. If the vibratory energy exceeds the strength of the valance bond between any two atoms of a molecule, this valance bond will be broken, decomposing one larger molecule into two smaller molecules. This is the first step in the ordinary cracking reactions. This is followed normally by polymerization of some of the molecules and further cracking of others, so that finally we end up with both lighter and heavier constituents than we originally started with.

Figure 2

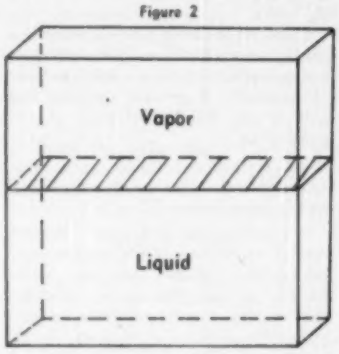
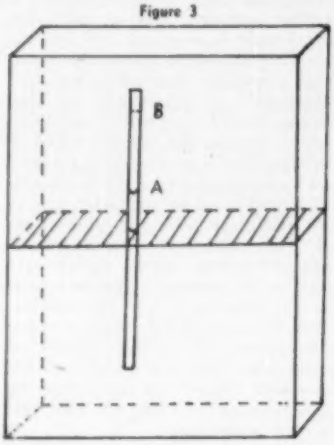


Figure 3



The attraction between the molecules becomes very important in the liquid phase. Assuming a closed container such as shown in Figure 2 in which there is a liquid and above this liquid only molecules of that liquid in the vapor phase.

In the liquid phase there is a high concentration of the molecules and, at low pressures, in the vapor phase a very low concentration of the molecules. Molecules in the liquid phase in the body of the liquid are completely surrounded by similar molecules so that the attractive forces of any given molecules within the body of the liquid are completely neutralized by forces from the surrounding molecules. Now consider the surface film, immediately it is seen that the molecules in the surface film will be strongly attracted downwards by the mass of molecules underneath this film, but very slightly attracted by the relatively low density of the molecules in the vapor phase above this surface.

This will tend to pack the molecules on the surface and form a relatively tough skin on the surface of the liquid. The packing of the molecules to form this tough skin on the surface

Process area of the Big Lake, Texas, Plant of Barnhart Hydrocarbon Corporation.

is readily demonstrated by floating an oily needle on the surface of a glass of water. It is also noted in nature where a number of insects are found that will skate over the surface of the water. This surface layer supports the needle or these insects provided it is not punctured or that the needle or the feet of these insects are not wet by the water.

This surface film tends to retard the escape of molecules from the surface into the vapor phase. Speaking of the velocity of molecules previously the term "velocity of molecules" has been used in such a way that it might be assumed that all the molecules would have the same velocity. This is not true. What is normally meant by "velocity of the molecules in a gas" is their mean velocity at any instantaneous time, some of the molecules may be stationary, others traveling at relatively low velocities, others traveling at very high velocities. The average velocity of the molecules defines the temperature. In the liquid phase, therefore, there are some molecules of very high velocities; therefore very high energies. If these molecules of high energy strike the surface layer normal to the surface, they will have enough energy to break through the surface layer and escape into the vapor phase. Likewise molecules in the vapor phase having sufficient energy can return to the liquid phase. What there is in reality under these conditions is a dynamic, not a static, equilibrium between the liquid and vapor phase, in that liquid molecules are continually escaping into the vapor phase and vapor molecules are continually returning to the liquid phase.

As there are vapor molecules above the liquid due to this escape from the liquid there must be a pressure exerted in the space above the liquid in the closed container. The pressure exerted by these vapor molecules is known as the vapor pressure of the liquid. This vapor pressure of the liquid in reality is a measure of the tendency of the liquid to pass into the vapor phase. As the temperature is increased it is quite obvious that there will be more molecules tending to escape into the vapor phase, as there will be more molecules with sufficient energy to break through the surface layer. As more molecules break through the surface layer into the vapor phase, there are more molecules in the vapor phase to produce an attractive force upwards on the surface film thereby reducing the toughness of this film.

This again permits lower velocity molecules to escape. As additional heat is put into the liquid, more and more molecules will escape into the vapor phase. As more molecules are packed into the volume above the liquid the attractive forces at the surface are gradually decreasing until finally a temperature is reached at which the molecular density becomes a constant throughout the vessel. At this point the dividing line between liquid and vapor vanishes. This temperature is defined as the "critical temperature" of the liquid. The vapor pressure at this temperature is defined as the "critical pressure."

The unbalanced forces on the surface of the liquid producing the highly packed film are known as the "surface tension" of the liquid. The surface tension then in reality is the force required to break this film.

The surface tension of a liquid gives the direct explanation of capillary attraction. It can be readily understood that from this surface of highly packed molecules there is produced a downward force exerted normal to the surface of the liquid. This downward force produces what is known as the internal pressure of the liquid. If there was some method of destroying the full force or part of the force of surface tension over a part of the surface of the liquid, the liquid would rise at this point above the level of the surrounding liquid.

Consider a situation as indicated in Figure 3 in which there is a small diameter tube commonly known as a capillary tube extending through the surface of the liquid, part of the tube being above the liquid and part below the surface of the liquid. It is observed that the liquid will rise in the small tube to some point as at A.

The surface of this liquid is not flat, but curved downward from the side walls. If the forces exerted by surface tension on this small area of surface are analyzed it will be seen that these forces only exert relatively small vertical downward force as all of these forces are acting normal to the surface. As a result a large proportion of the force of the surface tension is exerted at a angle to the bore of the tube. Some of the forces of the molecules in the surface layer are partially neutralized by the walls of the tube. Therefore, the downward thrust of these forces in the small tube is less than the downward thrust in the main body of the liquid where the surface forces are all acting normal to the surface and are not neutralized by any surface wall. If there is less downward thrust within the small tube than outside the tube the liquid will rise in the tube above the level of the liquid in the main container. If the size of the bore of the tube is reduced the liquid will rise to some point as *B*, and if the diameter of the tube is fur-

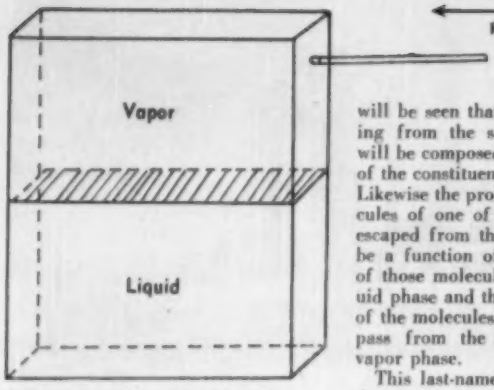


Figure 4

ther reduced, the liquid will rise to heights even in excess of that of barometric column of that liquid.

The term "capillary attraction" then is a misnomer as there is no true attraction and the rise of the liquid is due to the internal pressure of the liquid forcing the liquid up a small tube where the full force of surface tension is not permitted to exert itself vertically.

The above discussion is based on the assumption that the side walls of the small tube are wet by the liquid. If the walls of the small tube are not wet by the liquid, the surface of the liquid will be depressed within the smaller tube. The curved surface of the liquid in a tube is called the meniscus.

In a system such as shown in Figure 4 containing a liquid in equilibrium with its vapor and heat is applied to the liquid, the heat will be absorbed by the liquid as specific heat until the liquid starts to boil. If the vapors are removed at a constant pressure, a pure component will continue to boil at constant temperature. The heat necessary to change from the liquid phase to the vapor phase is known as the "latent heat of vaporization."

The latent heat can be expressed by a mathematical expression similar to one used for specific heat.

$$\text{Latent Heat} = \Delta H + \int PdV$$

In this equation ΔH is the energy required to transport a molecule from the body of the liquid to the surface and break it through that surface layer. $\int PdV$ represents the amount of energy required to decrease the density of the fluid from the liquid phase to the vapor phase.

Dalton's law of partial pressures in the vapor phase is complemented by a similar law in the liquid phase known as Raoult's law.

In considering vapor pressure above the discussion was confined to a pure substance. If the liquid in Figure 2 is a mixture of two components, it will be seen that the molecules escaping from the surface of this liquid will be composed of molecules of both of the constituents in the liquid phase. Likewise the probability that the molecules of one of the constituents have escaped from the liquid phase would be a function of the relative number of those molecules present in the liquid phase and the activity of tendency of the molecules of that constituent to pass from the liquid phase to the vapor phase.

This last-named property would be the vapor pressure of the constituent in the pure state. Raoult expressed this function by saying that the partial vapor pressure of any constituent from the liquid phase is equal to the mol fraction of that constituent in the liquid phase times the vapor pressure of that constituent as a pure component. Expressed mathematically this becomes:

$$PVP = PX$$

where PVP is equal to the Partial Vapor pressure P = vapor pressure of pure constituent X = mol fraction in the liquid phase.

Where there is a mixed gas in equilibrium with a liquid the partial pressure of any constituent is the force tending to make this constituent return to the liquid phase. The partial vapor pressure is the tendency of that constituent in the liquid phase to pass into the vapor phase. For equilibrium these two must be equal. This means that the same number of molecules are escaping from the liquid into the vapor phase as are condensing from the vapor phase into the liquid.

Therefore, for equilibrium between liquid and vapor the partial pressure of each constituent in the vapor phase must be equal to the partial vapor pressure of that constituent in the liquid phase.

The partial pressure as defined previously from Dalton's Law is equal to πY. Where π is equal to total pressure on the system and Y is the mol fraction in the vapor phase. The equation for equilibrium then becomes

$$\pi Y = PX$$

This equation πY is equal to PX is the basis of all equilibrium calculations and is the fundamental equation used in process work. The equation PX is equal to πY is for ideal vapors and ideal liquids. Unfortunately we never encounter these ideal conditions in practice. However, we do know from experimental work what correction factor to apply to this equation to make it applicable to actual problems.

We may arrange this formula into the form

$$Y/X = P/\pi = K$$

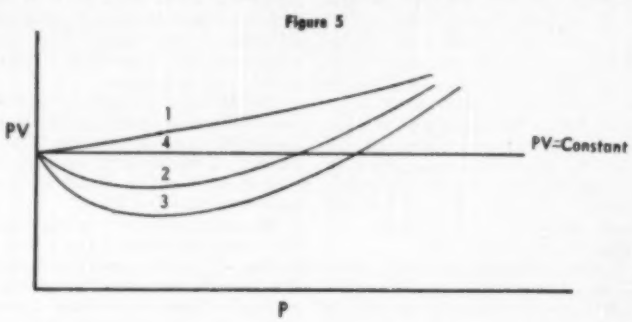
where K is our equilibrium constant.

This K then is the ratio between the mol fraction in the vapor phase and the mol fraction in the liquid phase at a given temperature and pressure, and as such has no bearing on the relative amounts of material in the vapor or liquid phase. K is solely a compositional constant. There are charts which give the value of K for various temperatures and pressures for most of the hydrocarbons and other gases. These curves are being extended and corrected from time to time.

One of the most important deviations from the perfect gas laws that has to be dealt with is the compressibility of the gas, sometimes erroneously referred to as "supercompressibility."

If a plot of the function PV against P is made a family of curves such as shown in Figure 5 is obtained. If the gas were to follow the perfect gas laws PV would equal a constant and be represented by curve 4. Curve 1 would be for a gas at a relatively high temperature with respect to its critical temperature, curve 2 at a lower temperature, and curve 3 at a still lower temperature. Curves 2 and 3 through a certain pressure range would show a lower volume than that expected from our perfect gas laws. While at still

Figure 5



higher pressure they would show a volume greater than that expected from the perfect gas laws. If the temperature is sufficiently high the volume occupied by the gas would always be in excess of that calculated from the true gas laws. As a matter of interest, curve 1 represents the general form of the compressibility of hydrogen at ordinary temperatures. At greatly reduced temperatures hydrogen will follow curves as represented by 2 and 3. It has been found that the value of *PV* for all gases varies as a function of the critical temperature and critical pressure.

A great many of the physical properties of substances can be correlated by what is known as "the law of corresponding states." This law of corresponding states is that at the same reduced temperature and reduced pressure all substances have the same physical properties. The reduced temperature is the actual absolute temperature divided by the absolute critical temperature. The reduced pressure is equal to the total absolute pressure divided by the absolute critical pressure.

Expressed in a mathematical form:

$$T_r = T/T_c$$
$$P_r = P/P_c$$

where T and P are the absolute temperature and pressure respectively T_c and P_c are the absolute critical temperatures and pressures.

The critical temperatures and pressures of most substances are known and can be found in any handbook.

For a gaseous mixture a false or pseudo critical temperature and pseudo critical pressure are computed and it is found that this pseudo critical temperature and pseudo critical pressure defines the properties of that gaseous mixture accurately enough for most engineering work. The pseudo critical temperature of a gas mixture is equal to the sum of the mol fractions of each constituent times the absolute critical temperature of that constituent. Likewise the pseudo critical pressure of the gas is equal to the sum of the mol fractions of each constituent times its absolute critical pressure.

These have been curves drawn correlating pseudo critical temperature and PV/RT. This compressibility factor is referred to as *Z*, and applies a correction to our perfect gas equation.

$$PV = RT$$

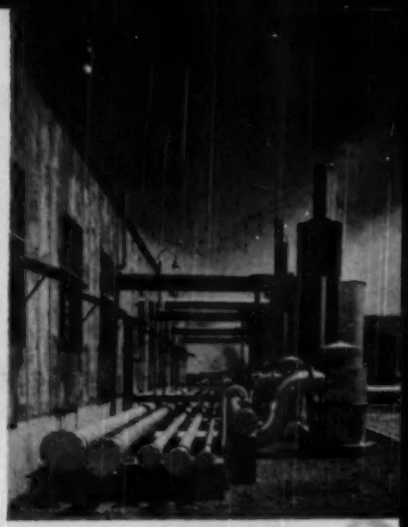
making this equation for actual gas read

$$PV = ZRT$$

When gas is compressed the temperature rises. This raise in temperature is due to overcoming the internal forces of the gas and kinetic energy increase. Due to the attractive force between the molecules the gas volume normally decreases more than the pressure would indicate by the factor of van der Waal's equation of A/V^2. This attractive, apparent pressure, force expresses itself as heat during the compression cycle. In most of the present day compressors operating in the medium pressure range, especially those of the high speed type, gas compression takes place at substantially constant entropy as the heat lost to the cylinder walls is very small with respect to the total energy input. In some of the very high-pressure cylinders the bore is very small and so the cooling surface with respect to the total volume is large resulting in an appreciable heat lost to the cylinder wall. The converse of the above is true as a gas is expanded through some type of engine in which work is taken out, the gas temperature will drop. This drop in temperature will be proportional to the amount of work removed from the gas during its expansion.

If the gas is expanded through a nozzle where no external work is done, cooling also results. Such an expansion through a nozzle takes place with an increase of entropy. In this expansion a drop in temperature is observed but this drop of temperature is not as great as we would obtain from taking work out of the gas during its change of pressure. The amount of work done on expanding the gas through a nozzle is solely the work to overcome the internal forces of the gas and is expressed by $\int PdV$. The small amount of energy on direct expansion is used up in increasing the velocity of the molecules from the velocity of approach to the nozzle to the velocity leaving the nozzle. If expansion takes place directly into air this amounts to the energy required to lift the atmosphere corresponding to the amount of gas expanded through the nozzle.

Figure 5 shows that some gases will expand more than would be expected from the perfect gas laws. Gases that follow curves 2 and 3 of this Figure 5 will show a greater drop in temperature on expansion through a nozzle than gases that follow curve 1 or curve 4. This is because the expansion that takes place is greater than would be expected from the perfect gas laws. As was previously pointed out the greater the initial temperature of the gas the smaller the deviation from the perfect gas laws. Therefore, gas that has been previously cooled will show a greater temperature drop on free expansion through a nozzle than one that is initially at a higher temperature. This property of the gases is made use of in liquefying our so-called "fixed gases." If a gas under high pressure is passed through one side of a heat exchanger then expanded, and the expanded gases returned through

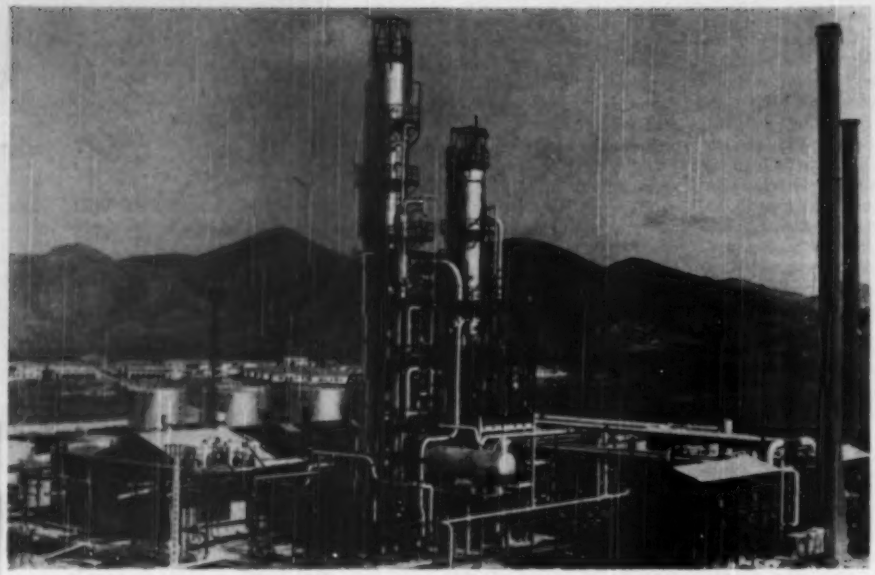


Compressor Utilities — Exhaust Silencers, Air Intake Scrubbers, Lube Coolers, Fuel and Cooling Water Headers at the Big Lake plant of Barnhart Hydrocarbon Corporation.

the other side of the heat exchanger, the cooled expanded gases will absorb heat from the high-pressure gas and cool it before expansion. This cooled high pressure gas upon expansion will cool still further so the process becomes progressive until finally a temperature is reached at which the high pressure gas is liquefied and only part of it is reconverted into very cold vapor to return through the heat exchanger. The remaining portion can be drawn off as a liquid. This method is extensively used in the production of liquid air. In the production of liquid air the initial pressure is usually of the order of 3000 psi. At this pressure the air is thoroughly dried and freed of all traces of carbon dioxide which, unless removed, would solidify in the heat exchanger and expansion nozzle, completely shutting down the operation of the equipment.

If a gas such as hydrogen in a similar apparatus is used with the initial temperature of the gas entering the equipment that would normally be obtained by water cooling, no refrigeration would be produced upon expansion. In fact, the hydrogen would actually increase in temperature passing through the nozzle. If, however, the hydrogen were precooled to the temperature of liquid air prior to expansion a further cooling will take place upon passing through the nozzle and finally the temperature would be reduced to the liquefying point of hydrogen. The cooling obtained by direct expansion was first measured in experiments by Joule and Thomson, and is known as the Joule-Thomson effect.

End of Part I. Part II will appear in an early issue.



Two-Stage Distillation Unit at REPESA Refinery, Cartagena, Spain. A huge expansion program has been announced for this plant.

Caltex Affiliate in Spain To Double Capacity of Plant

No U. S. Government Funds Involved

REFINERY capacity of the California Texas Oil Company affiliate in Spain will soon be increased by possibly 50 percent over the previous planned 20,000 barrels per day.

It marks the second time this year that an increase has been decided for the Cartagena facilities of Refineria de Petroleos de Escombreras, S. A. (REPESA) in which Caltex holds a 24 percent interest.

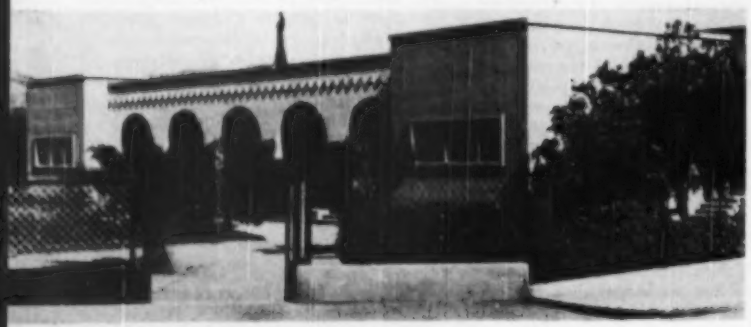
REPESA, whose principal ownership lies in the hands of a Spanish government agency, Institute Nacional de Industria, was organized in June, 1949.

In January, 1950, the Cartagena plant was put into operation charging 5000 barrels a day of crude and producing motor gasoline, kerosine, Diesel gas oil and fuel oil. Shortly afterward, it was decided to expand to 20,000 barrels a day with anticipated date for completion of the new facilites April, 1952. Now the technical and engineering departments are setting out to draw new plans for expanding still further with the new date and the final capacity not yet decided.

REPESA president Jose M. DeLapuerta has already estimated that Spain would save around $8 million annually in foreign exchange normally spent for imported petroleum products, now coming from the Escombreras refinery.

The plant is located just outside of Cartagena in what was formerly a barren valley. In the middle of 1948, discussions began for the building of a refinery where some work had already been begun. The Institute Nacional de Industria assumed 52 percent of the ownership while Caltex and a Spanish concern, Compania Espanola de Petroleos, S. A., each assumed 24 percent. The formation of REPESA climaxed 15 years of Caltex operations in Spain. Within ten months details were worked out and given official sanction as necessary to the industrialization of Spain. Authorized capitalization was 325,000,000 pesetas. Caltex' investment is en-

Exterior of Cartagena Refinery Cafeteria.



tirely its own and no U. S. government funds are involved.

Among the primary responsibilities of Caltex was the supplying of crude oil which has come and is now coming from Arabian sources. When the first phase of construction was completed, plans for expansion were already underway and output has been running at 300,000 tons of products annually, according to W. F. Bramstedt, Caltex president.

Besides the refinery itself, construction included living quarters for workers, recreational facilities, schools and churches. With each living quarter came electricity, hot and cold water, a patio and a vegetable plot.

Classification Tanks, Cartagena Refinery, Spain

Technical Data

Facilities already planned within the next 18 months include an atmospheric distillation unit, a thermal reformer, a catalytic polymer plant and complete facilities for the manufacture of automotive and industrial lubricants.

The lubricating oil plant, in the discussion stage at present, would call for a yearly capacity of 20,000 tons of products.

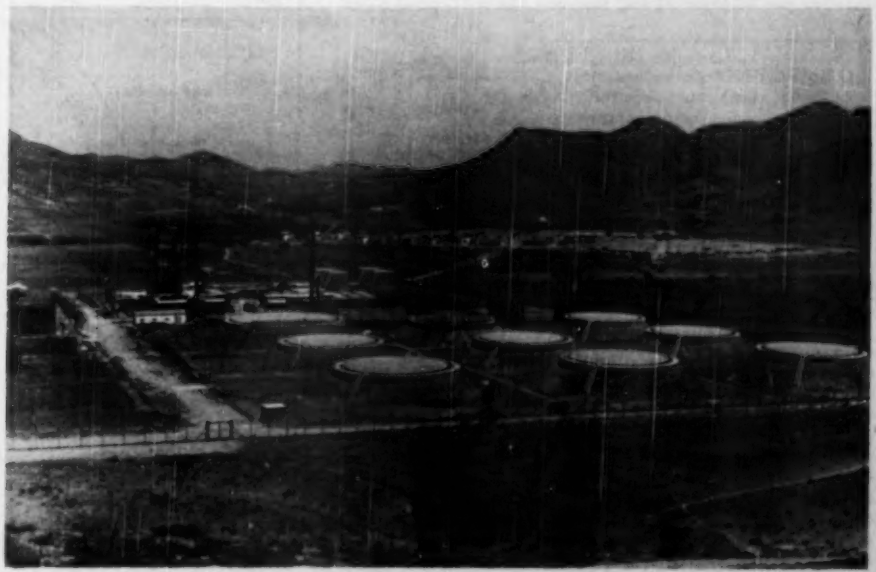
The crude distillation unit will have a gasoline rerun column and stabilization. Designed to handle in excess of 20,000 barrels a day, the overhead gasoline from the two crude units will be rerun into light and heavy gasoline with the light later being stabilized.

A reformer unit will be designed to improve the octane number and volatility of the heavy straight-run gasoline. It will have vaporized clay facilities to treat the reformed product assuring a color for the product of water whiteness. The recovery of C-3 and C-4 olefins for feed to the catalytic polymerization unit and stripping the residue to improve gasoline fractions will be provided for. It will handle 6000 barrels daily when reforming 210°-400° F. heavy gasoline to produce the debutanized 400° F. endpoint gasoline. This will have a clear octane number of 70 (ASTM F-2).

Color improvement, incidentally, will be done through the use of Gray Towers.

The catalytic polymerization unit will process 350 barrels daily. C-3 and C-4 olefins recovered from the reformer will be processed in it.

Bramstedt said the operations in Spain had worked out successfully and that the relations begun at the time of initial negotiations "created a feeling which will unquestionably result in a satisfying outcome for our investments in Spain."



General View of Caltex Affiliated Company Refinery in Cartagena, Spain.

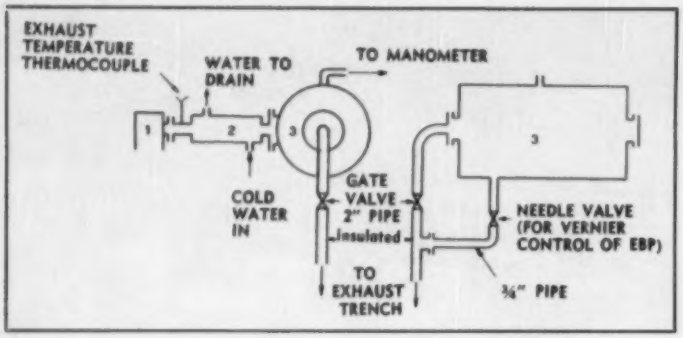


Figure 1. Exhaust System Employed in Exhaust Back Pressure Studies. 1) Supercharged CFR Engine; 2) Accordion-Type Water Jacket; 3) Regular CFR Exhaust Surge Chamber (Screened for Safety).

Influence of Exhaust Back Pressure On Antiknock Performance Of Aviation Fuels

W. E. MORRIS

Esso Laboratories—Research Division,
Standard Oil Development Company,
Linden, N. J.

COMPOUND power plants utilizing both reciprocating piston engines and exhaust gas turbines are expected to play a considerable part in our aviation fuels field in the immediate future. This study reports investigations into the behavior of typical aviation gasolines in such power plants.

THERE seems to be little question today that the gas turbine engine will predominate as the aircraft powerplant of the future. Present design turbo jet engines, however, have rather high fuel consumption characteristics and it therefore can be expected that the reciprocating engine will be relied upon, for some time to come, to power extremely long range aircraft. The fuel economy of the reciprocating engine, moreover, can be significantly improved by the utilization of a feature known as "compounding." Compound engines deliver power both from a conventional reciprocating engine and from one or more gas turbines driven by the exhaust from the reciprocating engine. The presence of a turbine in the exhaust system, however, increases the exhaust back pressure imposed on the reciprocating engine, thus causing an increase in the temperature and amount of hot residual gas remaining in the combustion chamber to mix with the incoming fuel-air charge. This, of course, affects the anti-knock performance of the fuel in the reciprocating engine part of the compound engine.

To determine just how large this effect would be, a series of experiments were carried out by the Research Division of the Esso Laboratories in a supercharged CFR engine, equipped to operate at varying exhaust back pressure. The results of these studies indicate that the rich mixture (peak) knock-limited power obtainable from the fuels tested is very insensitive to exhaust back pressure. On the other hand, an increase in exhaust back pressure causes a considerable decrease in lean mixture (minimum point) knock-limited power. This effect is somewhat less pronounced for the "insensitive" fuels.

Mixture response curves of knock-limited power vs. fuel/air ratio were obtained on each of the five fuels tested at 7:1 and 8:1 compression ratio

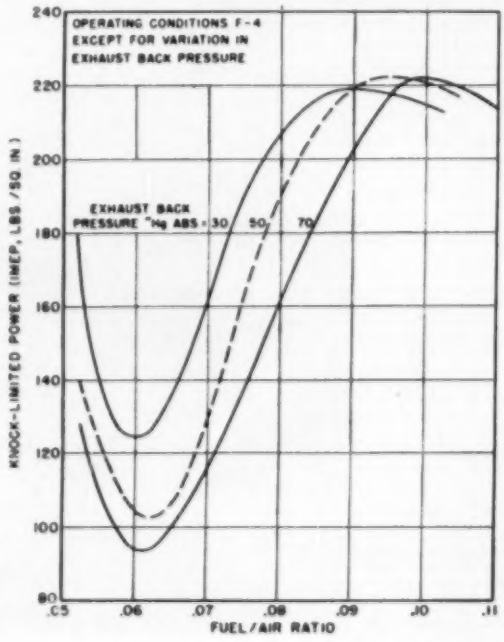


Figure 2. Effect of Exhaust Back Pressure on Knock-Limited Power of Fuel, 28 R (Grade 106/130 "Referee" Fuel).

over a range of exhaust back pressure from 30 inches to 90 inches mercury absolute. Each mixture response curve was obtained at a given exhaust back pressure which was maintained constant by means of a throttling valve in the exhaust line as illustrated in Figure 1.

Standard F-4 (see CRC Handbook), operating conditions were employed in these studies, except for the variations in exhaust back pressure and compression ratio. It is appreciated that the lean end of the F-4 curve is subject to variations from laboratory to laboratory but all of the data reported herein were obtained on the same engine and with special precautions taken so that on a relative basis, the comparison between fuels and conditions should be valid. The test fuels investigated are listed in Table 1.

TABLE 1

FUEL	Performance No. Lean (F-3)	Rich (F-4)
Isooctane Clear	100	100
Isooctane + 4 cc tel./gal.	152	152
28R (Grade 100/130 "referee" fuel)	100	130
33R (Grade 115/145 "referee" fuel)	115	145
Special Fuel*	129	156

*85 vol. percent C_8 alkylate C_8 cut, 15 vol. percent isopentane, and 4 cc. tel. per gallon.

The typical effect of exhaust back pressure on knock-limited performance is exemplified by the data shown in Figure 2 on Grade 100/130 fuel 28R. An increase in exhaust back pressure causes a large decrease in lean mixture knock-limited power (indicated mean effective pressure or IMEP). At rich mixtures, the peak knock-limited power occurs at progressively higher fuel/air ratios as exhaust back pressure is increased, although the magnitude of the peak IMEP is relatively unaffected. Lean and rich knock-limited powers at the three exhaust back pressures are shown in Table 2.

TABLE 2

Exhaust Back Pressure, "Hg. Abs.	Grade 100/130 Knock-Limited Power (IMEP) Lean (0.06 F/A)	Peak Rich
30	124	219 (0.089 F/A)
50	103	222 (0.095 F/A)
70	93	222 (0.100 F/A)

The magnitude of the lean mixture knock-limited power decrease in the case of Grade 100/130 and 115/145 fuels at 7:1 compression ratio is approximately 0.5 per cent per inch Hg. exhaust back pressure increase, based on data shown in Table 3.

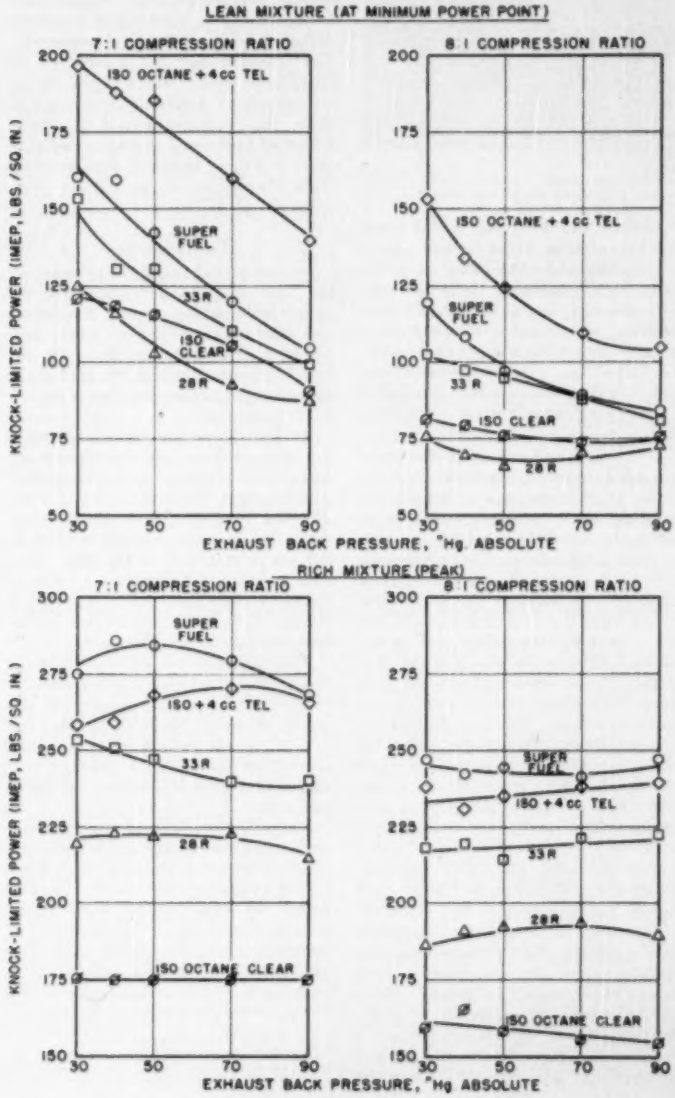
TABLE 3
Lean Mixture Knock-Limited Power (IMEP) at Minimum Power Fuel/Air Ratio

GRADE	7:1 Compression Ratio 30 "Hg	7:1 Compression Ratio 90 "Hg	8:1 Compression Ratio 30 "Hg	8:1 Compression Ratio 90 "Hg
100/100	121	92	82	75
100/130	124	87	75	72
115/145	148	98	102	82
129/158	163	105	118	85
152/152	197	141	153	104

These results are taken from Figure 3, at left, which shows that under lean mixture conditions relatively uniform decreases in knock-limited power are obtained over the range of exhaust back pressure from 30 inches to 90 inches mercury absolute. The influence of exhaust back pressure is less at 8:1 than at 7:1 compression ratio, due presumably to the lesser amount of residual gas present as well as its lower temperature at the higher compression ratio.

Under rich mixture conditions, the

Figure 3. Effect of Back Pressure on Knock-Limited Power (IMEP). (Operating conditions F-4 except for Compression Ratio and Exhaust Back Pressure.)



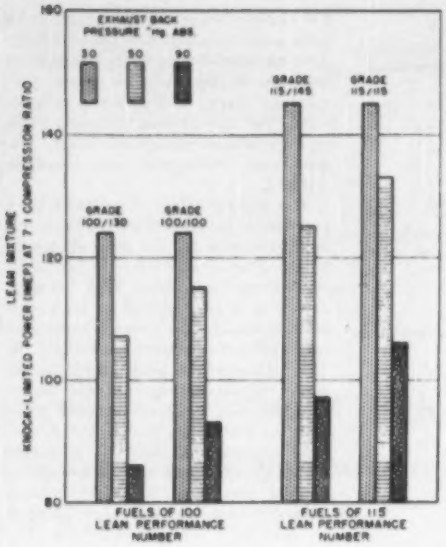


Figure 4. Effect of Exhaust Back Pressure on Lean Mixture Antiknock Performance at Various Fuel Quality levels. (Paired data from Figure 3.)

peak knock-limited power is not greatly affected by exhaust back pressure at either 7:1 or 8:1 compression ratio, as shown in Figure 3. The lesser effect of exhaust back pressure at rich mixture compared to lean mixture conditions can be attributed to two factors:

(1) Lower temperature sensitivity of fuel at rich mixture conditions.

(2) Lower residual gas temperature at rich mixture conditions.

Apparently, under rich mixture conditions, the heating effect of the residual gas is almost exactly counterbalanced by its dilution effect, the latter tending to increase knock-limited power.

The test fuels fall into two groups: conventional aviation fuels with a "rich mixture appreciation" of 30 performance numbers, and the very insensitive isooctane and isooctane + 4 cc. tel. per gallon with zero "rich mixture appreciation." This wide difference in fuel type was chosen for study to reveal differences in sensitivity of fuels to exhaust back pressure. In this connection, the test results indicate that the lean mixture knock-limited power outputs of the "insensitive" fuels are somewhat less affected by exhaust back pressure at 7:1 compression ratio than those of the conventional aviation fuels.

This is illustrated by Figure 4 which shows the effect of exhaust back pressure on lean mixture knock-limited power obtainable in the supercharged CFR engine for various fuels. For example, these faired data indicate that a fuel of 115 F-3 lean performance number gives a knock-limited power of approximately 145 IMEP at an exhaust back pressure of 30 inches mercury absolute, but at an exhaust back pressure of 90 inches mercury absolute, the knock-limited power drops to 97 IMEP for a conventional Grade 115/145 fuel compared to 106 IMEP for an "insensitive" (Grade 115/145) fuel.

If a compound engine is developed around a certain conventional reciprocating aviation engine and factors such as intake air temperature, compression ratio, etc. are held constant, the lean mixture antiknock quality requirement will be increased due to the exhaust back pressure imposed on the reciprocating engine by the exhaust gas turbine. In this connection, the Supercharged CFR engine data indicate that if the exhaust back pressure imposed on a 7:1 compression ratio engine requiring Grade 100/130 fuel is increased from atmospheric (30 "Hg abs.) to 50 "Hg abs., the lean mixture antiknock requirement is increased from 100 to about 115 performance number. This can be seen from Figure 4 which indicates a knock-limited power of about 125 IMEP for both Grade 100/130 fuel at 30 "Hg abs. and Grade 115/145 fuel at 50 "Hg abs.

It would, of course, be possible to counteract the effect of higher exhaust back pressure on lean mixture antiknock requirements by proper design of the compound engine to minimize the severity of operating conditions from some other standpoint. By way of example, it is estimated from the results of Supercharged CFR engine studies that a decrease in intake air temperature of roughly 50° F. would counteract the effect on antiknock requirement of a 10 "Hg abs. increase in exhaust back pressure. A second method of decreasing engine severity is to lower compression ratio. For example, Grade 115/145 fuel 33R has approximately the same knock-limited power at 7:1 compression ratio and 90 "Hg abs. exhaust back pressure as at 8:1 compression ratio and 30 "Hg abs. exhaust back pressure. Thus, if compression ratio is decreased by roughly 0.2 of a unit for each 10 "Hg abs. increase in exhaust back pressure, the lean mixture antiknock requirement of the engine is maintained constant. Although some of the improvement in fuel economy due to the recovery of the exhaust energy would be lost by an accompanying decrease in compression ratio, this decrease would be minimized at high back pressures because more power is available for recovery from the exhaust gas at a lower compression ratio.

Conclusions

Increasing exhaust back pressure in the Supercharged CFR engine has no appreciable effect on the maximum rich mixture knock-limited power output of aviation gasoline. However, the Fuel/Air ratio at which the maximum power output occurs is richer at higher back pressures.

At lean Fuel/Air rations, increasing exhaust back pressure causes an appreciable decrease in knock-limited power output. For Grade 100/130 and 115/145 fuels at 7:1 compression ratio, this decrease amounts to roughly 0.5 per cent per " of Hg back pressure increase. The decrease in knock-limited power obtained by increasing exhaust back pressure becomes less as compression ratio is increased.

The magnitude of lean mixture knock-limited power decrease with increasing exhaust back pressure depends to some extent upon the type of fuel under consideration. A very insensitive fuel such as isooctane is affected less than conventional aviation gasoline.

The adverse effect of high exhaust back pressure on antiknock performance of aviation gasoline in a compound aircraft engine can be counteracted, for example by decreasing compression ratio or intake air temperature. Thus, the actual gasoline antiknock quality requirement of a compound engine is primarily in the hands of the powerplant designer.

NOTE:

The Author's present address is E. I. du Pont de Nemours Petroleum Laboratory, Chambers Works, Pennsgrove, N. J.

Planning Refinery Heat Transfer Equipment

Part II

Efficiency and Operating Relations

TYLER G. HICKS
Hicks Associates, New York

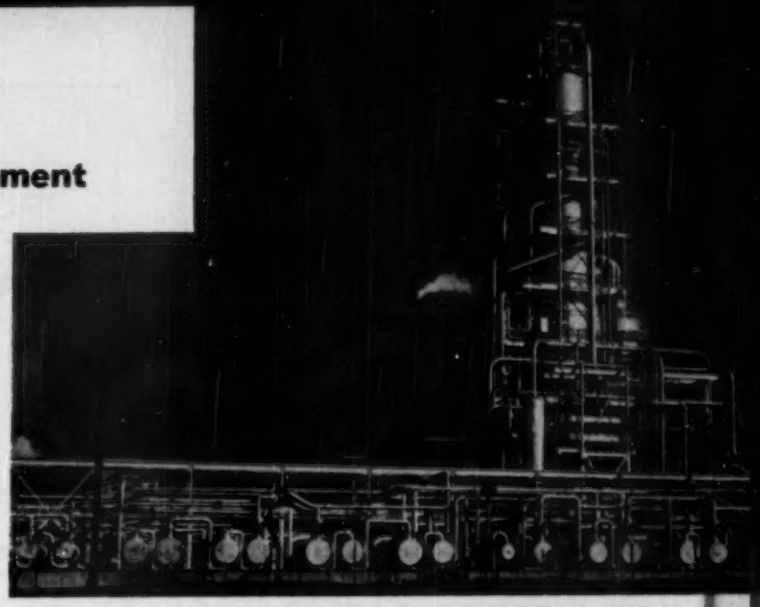


Figure 1. Battery of Heat Exchangers Located Adjacent to a Refinery Pipe Still. Many of these units are standardized exchangers. Photo courtesy Standard Oil Company (New Jersey).

THE rate of heat transfer through a flat plate or an exchanger tube depends directly on the temperature difference between plate or tube surfaces. For cases where the temperatures on both sides of the surface remain constant, the rate of heat transfer is uniform for the entire surface. Also, the effectiveness of each unit of area is equal to that of any other.

For the more general case of heat transfer in refinery equipment, the temperatures of both fluids change as they move across the surface. Since heat transfer rates vary with temperature difference, the effectiveness of any given unit of area depends on the temperature difference across it. The difference changes with flow, causing surface effectiveness to change with flow. Consequently, although the amount of heat transferred increases with area, there is a limit beyond which further addition of area may prove uneconomical. The initial cost of additional heating surface, the greater attendance and maintenance required, offset any gain resulting from increased heat transfer. For this reason it is necessary to recognize the importance of efficiency expressions which can readily be compared.

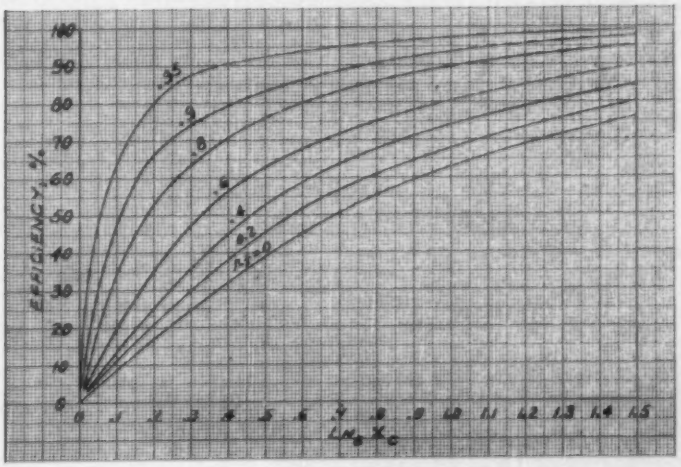
Assume two refinery heat exchangers, both suitable for the same heating range and fluids. One has an over-all coefficient of heat transmission of U_g, the other, U_L. Since both exchangers are capable of heating the same quantity of fluid through the same temperature range, the exchanger with the greater value of over-all coefficient, U_g, is more efficient than that with the lesser value, U_L. Therefore, it can be said that the over-all coefficient of heat transmission, U, is a good basis for comparison of the efficiencies of two heat exchangers. Of course, the heaters compared must be of similar construction and must have similar flow conditions throughout; otherwise the comparison is meaningless.

Use of the over-all coefficient of heat transfer, while satisfactory for rough comparisons, does not give any numerical estimate of how close the exchanger approaches the maximum efficiency obtainable. Efficiency equations, however, can be used to determine the actual numerical value of exchanger efficiency.

Extreme care must be exercised when discussing the efficiency of a given heat exchanger because the maximum value obtainable might be less

THE FIRST part of this article presented the basic relations encountered in preliminary design of refinery heat transfer equipment. From data given there, most ordinary sizing problems can be solved. Besides these basic relations, there are many others which aid in determining equipment efficiency and probable operating conditions. Equipment efficiencies and operating conditions are of importance to all refiners because annual costs are a direct function of day-to-day operation.

Figure 2. Chart for evaluating Ln X for use in the operating equations given in this article. The heat transfer equipment efficiency is either assumed or made equal to that of similar equipment.



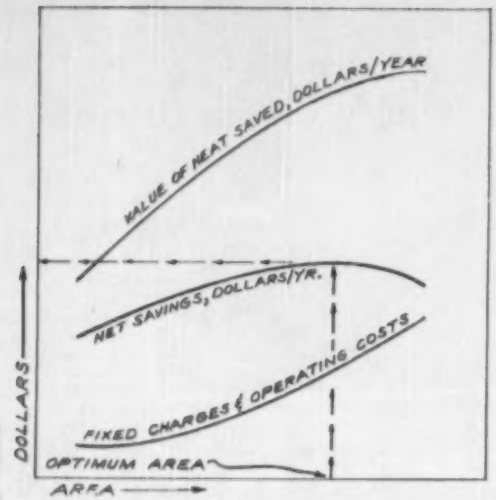


Figure 3. Cost curves for determining the optimum area of heat transfer surface. The most economical area is that which produces the maximum net annual savings.

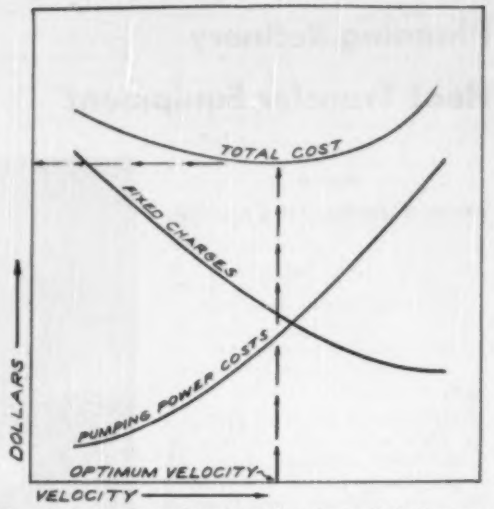


Figure 4. Cost curves for determining the optimum velocity in process exchangers. The most economical velocity is that which produces the minimum annual total cost.

than 100 percent. For this reason the efficiency must be based on the actual amount of heat available for transfer at the given operating conditions. Table 1 summarizes efficiency equations for four of the five cases of heat transfer discussed in the first part of this article. These equations are readily adaptable to actual operating conditions because they permit determination of exchanger efficiencies when external heat losses are negligible, when they are of sufficient magnitude to be considered, or when there is heat gain. Before illustrating uses for these equations, operating relations will be given.

In many refining, natural gasoline, and petrochemical applications, the desired efficiency of a heat exchanger is established first and then the area and fluid outlet temperatures which will be obtained are computed. Such computations have many applications. For instance, after establishing a group of efficiency values, the necessary areas are computed and plotted against the obtainable outlet temperatures. With plots such as these on hand for fluids commonly used in the plant, the necessary area for any outlet temperature is readily obtained. Then, from a listing of standard heat exchangers, a proper size unit can be chosen and piping arranged to serve it. Of course, similar calculations will be made by the heater manufacturer before guarantee of the unit is given, but the results of the two calculations will not, in general, differ markedly.

Table 2 summarizes operating equations for all cases discussed in the first part of this article. Note that Cases I, II, and V have been generalized so that they could be included under the paralleled flow heading. Study of the table shows that any one of 16 factors can be determined by substitution of proper values. It should be noted that the only equations which might differ in results from manufacturers' values are those involving the over-all coefficient of heat transfer, U. Hence, the value of U must be carefully chosen to prevent major discrepancies in results.

By conducting tests on existing heat exchanger equipment, petroleum refiners have an excellent chance to approximate actual values of U obtainable. As was shown in Part I, U varies with scale deposits, nature of the fluids heated or cooled, and fluid velocities. Many published values of U are based on scaling conditions in only certain parts of the country. These conditions may differ markedly from those at the plant site. Therefore, local U values are better than others whose accuracy is doubtful, provided the local values are for the same fluid, a similar exchanger, and about the same temperature range.

Table 1. Efficiency Equations.

	CASE I	CASE II	CASE III	CASE IV
NO HEAT LOSSES TO ATMOSPHERE	$e = \frac{t_2 - t_1}{t_A - t_1} = \frac{\theta_A - \theta_B}{\theta_A}$	$e = \frac{t_A - t_B}{t_A - t_1} = \frac{\theta_A - \theta_B}{\theta_A}$	$e = \frac{t_2 - t_1}{t_A - t_1}$, $W_h C_h > W_c C_c$ $e = \frac{t_A - t_B}{t_A - t_1}$, $W_c C_c > W_h C_h$	$e = \frac{t_2 - t_1}{t_A - t_1}$, $W_h C_h > W_c C_c$ $e = \frac{t_A - t_B}{t_A - t_1}$, $W_c C_c > W_h C_h$
WITH HEAT LOSSES OR GAINS TO OR FROM THE ATMOSPHERE				$e = \frac{t_2 - t_1}{t_A - t_1}$, $W_h C_h > W_c C_c$
(A) HEAT ADDED TO COLD FLUID	$e = \frac{t_2 - t_1}{t_A - t_1} = \frac{\theta_A - \theta_B}{\theta_A}$	$e = \frac{t_A - t_B}{t_A - t_1} - \frac{H}{W_c C_c (t_A - t_1)}$	$e = \frac{t_2 - t_1}{t_A - t_1}$, $W_h C_h > W_c C_c$ $e = \frac{t_A - t_B}{t_A - t_1} - \frac{H}{W_c C_c (t_A - t_1)}$, $W_c C_c > W_h C_h$	$e = \frac{t_A - t_B}{t_A - t_1} - \frac{H}{W_c C_c (t_A - t_1)}$, $W_c C_c > W_h C_h$
(B) HEAT REMOVED FROM HOT FLUID	$e = \frac{t_2 - t_1}{t_A - t_1} - \frac{H'}{W_c C_c (t_A - t_1)}$	$e = \frac{t_A - t_B}{t_A - t_1} = \frac{\theta_A - \theta_B}{\theta_A}$	$e = \frac{t_2 - t_1}{t_A - t_1} - \frac{H'}{W_h C_h (t_A - t_1)}$, $W_h C_h > W_c C_c$ $e = \frac{t_A - t_B}{t_A - t_1}$, $W_c C_c > W_h C_h$	$e = \frac{t_2 - t_1}{t_A - t_1} - \frac{H'}{W_h C_h (t_A - t_1)}$, $W_h C_h > W_c C_c$ $e = \frac{t_A - t_B}{t_A - t_1}$, $W_c C_c > W_h C_h$

Applications

Typical uses of the efficiency and operating equations are as shown below.

Example 1: A refinery counterflow exchanger will cool 90,000 pounds of gas per hour from 850° F. by heating 60,000 pounds per hour

of water from 120° F. How much area is required for an efficiency of 50 percent if the specific heat of the gas is 0.33, that of the water, 1.0, and U = 10?

Solution:

$$r_t = \frac{W_h C_h}{W_c C_c} = \frac{(90{,}000)\ (0.33)}{(60{,}000)\ (1.0)} = 0.495$$

Therefore, the equations for Case IVa, Table 2 apply.

Since the outlet temperatures of the fluids are not known, the log mean temperature difference cannot be found. Hence, the area relation,

$$A = \frac{W_h C_h}{U(1 - r_t)} \ln X_c$$

must be used. From Figure 2, $\ln X_c = 0.40$. Then,

$$A = \frac{(90{,}000)\ (0.33)\ (0.40)}{10\ (0.505)} = 2350 \text{ square feet}$$

Example 2: What are the terminal temperatures of the gas and water when the above heater operates under the given conditions and has the required area?

Solution: Using the equation for "n",

$$n = \frac{AU\ (1 - r_t)}{W_h C_h}$$

$$n = \frac{2{,}350(10)\ (1 - 0.495)}{90{,}000\ (0.33)}$$

$$n = 0.40$$

Then, using the equation for t_B,

$$t_B = t_A - (t_A - t_1)\left(\frac{1 - e^n}{r_t - e^n}\right)$$

$$= 850 - (730)\left(\frac{1 - e^{0.4}}{0.495 - e^{0.4}}\right)$$

$$t_B = 490° \text{ F.}$$

Using equation for t_2,

$$t_2 = t_1 + r_t\ (t_A - t_B)$$

$$= 120 + 0.495\ (850 - 490)$$

$$t_2 = 298° \text{ F.}$$

These two problems illustrate the typical solution procedure to be followed when using equations from Table 2. Where more than one equation is available for determining an unknown, the simpler one should always be used. After a little experience with the equations, it will be found that the results of any computation can be checked by means of one or more equations not used for the original calculation.

The best means for showing how the addition of area affects annual costs of refinery heat transfer equipment is by means of curves. Figure 3 correlates surface area, value of heat saved, operating costs, and fixed charges. The net saving which results from use of any given area is obtained by subtraction of investment and operating charges from the value of the heat saved. By plotting the numerical values of net savings, a convex curve is obtained. A vertical line drawn through the highest point of this curve to intersect the area axis gives the most economical area for the particular operating conditions.

One of the primary factors influencing the most economical area is the over-all coefficient of heat transmission, *U*. The over-all coefficient is, in turn, a function of the fluid velocity in the heat exchanger. Fluid velocity affects both U and the pumping power needed to force the fluid through the heat exchanger. High velocities increase the value of *U*, making each unit area of heat transfer surface more effective. However, as fluid velocities increase, so do pumping costs. Therefore, for every refinery heat exchanger there is a velocity value beyond which any increase in *U* is offset by higher pumping costs.

Figure 4 correlates velocity, power costs, investment charges, and total annual costs. Study of the curves shows that the optimum velocity is obtained when the total annual costs are a minimum. Special devices to maintain the most economical velocity through refinery, natural gasoline, or petro-chemical heat exchangers usually cannot be justified. Instead, it is common practice to size exchanger tubes to provide the most economical velocity for the normal flow rate and allow the heater to operate at other velocities during periods of sub-normal and abnormal loads.

When comparing the most economical parallel flow and counter flow heat transfer surfaces, care must be used to see that the basic limitations of each are not overlooked. If both fluids passing through the heater change temperature, the area required for parallel flow is always greater than that for counter flow, provided that equal amounts of heat are transferred. It is possible to prove this statement mathematically but a proof is unnecessary in this general discussion.

Manufacturers have standardized shell, tube, and head designs to reduce fabrication and equipment costs. In general, standardized heat exchangers are applied wherever possible in re-

Table 2a. Operating Equations for Heat Transfer in Engineering Apparatus. PARALLEL FLOW. (See Table 2b, next page for COUNTER FLOW.)

	CASE I $Nf = \infty$	CASE II $Nf = 0$	CASE IIIa $Nf < 1$	CASE IIIb $Nf = 1$	CASE IIIc $Nf > 1$	CASE V $Nf = \frac{W_h C_h}{W_c C_c}$
θ_A	$\theta_A = t_A - t_1$					
θ_B	$\theta_B = t_B - t_2$					
q	$q = UAt_m$					
q	$q = W_h C_h (t_A - t_1) = W_c C_c (t_2 - t_1)$	$q = W_h C_h (t_A - t_B) = W_c C_c (t_2 - t_1)$				
t_m	$t_m = \frac{\theta_A - \theta_B}{\ln \theta_A / \theta_B}$					
A	$A = \frac{q \ln \theta_A/\theta_B}{U(\theta_A - \theta_B)}$					
t_B	$t_B = t_A$	$t_B = t_A - e(t_A - t_1)$			$t_B = t_A - \frac{q}{W_h C_h}(t_2 - t_1)$	$t_B = t_A$
t_2	$t_2 = t_1 + e(t_A - t_1)$	$t_2 = t_1$	$t_2 = t_1 + e r_t (t_A - t_1)$	$t_2 = t_1 + e(t_A - t_1)$		$t_2 = t_1$
X, Y, & Z	$X_p = \frac{1}{1 - e}$	$X_p = \frac{1}{1 - e}$	$X_p = \frac{1}{1 - e(1 + r_t)}$	$Y_p = \frac{1}{1 - 2e}$	$Z_p = \frac{1}{1 - e\left(1 + r_t / N_f\right)}$	
n	$n = -\frac{AU}{W_c C_c}$	$n = -\frac{AU}{W_h C_h}$	$n = -\frac{AU(1 + r_t)}{W_h C_h}$	$n = -\frac{2AU}{WC}$	$n = -\frac{AU(1 + r_t)}{W_c C_c}$	
t_m	$t_m = \frac{q \theta_A}{\ln X_p}$	$t_m = \frac{q \theta_A}{\ln X_p}$	$t_m = \frac{q \theta_A (1 + r_t)}{\ln X_p}$	$t_m = \frac{2q \theta_A}{\ln Y_p}$	$t_m = \frac{q \theta_A (1 + r_t)}{\ln Z_p}$	$t_m = \theta_A = \theta_B$
A	$A = \frac{W_c C_c}{U} \ln X_p$	$A = \frac{W_h C_h}{U} \ln X_p$	$A = \frac{W_h C_h}{U(1 + r_t)} \ln X_p$	$A = \frac{WC}{2U} \ln Y_p$	$A = \frac{W_c C_c}{U\left(1 + r_t / N_f\right)} \ln Z_p$	
e	$e = 1 - \epsilon^n$		$e = \frac{1 - \epsilon^n}{1 + r_t}$	$e = \frac{1 - \epsilon^n}{2}$	$e = \frac{1 - \epsilon^n}{1 + r_t / N_f}$	
t_B	$t_B = \frac{t_2 - t_1}{1 - \epsilon^n} + t_1$	$t_B = t_A - \theta_A (1 - \epsilon^n)$	$t_B = t_A - \theta_A \left(\frac{1 - \epsilon^n}{1 + r_t}\right)$	$t_B = t_A - \theta_A \left(\frac{1 - \epsilon^n}{2}\right)$	$t_B = t_A - \theta_A \left(\frac{1 - \epsilon^n}{1 + r_t}\right)$ $= t_A - \frac{t_2 - t_1}{N_f}$	$t_B = t_A$
t_2	$t_2 = t_1 + \theta_A (1 - \epsilon^n)$	$t_2 = t_A - \left(\frac{t_A - t_B}{1 - \epsilon^n}\right)$	$t_2 = t_1 + r_t (t_A - t_B)$ $= t_1 + r_t \theta_A \left(\frac{1 - \epsilon^n}{1 + r_t}\right)$	$t_2 = t_1 + (t_A - t_B)$ $= t_1 + \theta_A \left(\frac{1 - \epsilon^n}{2}\right)$	$t_2 = t_1 + \theta_A \left(\frac{1 - \epsilon^n}{1 + r_t}\right)$	$t_2 = t_1$
θ	$\theta = \theta_A \epsilon^n$					

CASE IIIa $Nf<1$	CASE IIIb $Nf=1$	CASE IIIc $Nf>1$	
$\theta_A = t_A - t_2$			θ_A
$\theta_B = t_B - t_1$			θ_B
$q = UAt_m$			q
$q = W_h C_h (t_A - t_B) = W_c C_c (t_2 - t_1)$			q
$t_m = \frac{\theta_A - \theta_B}{\ln \theta_A/\theta_B}$			t_m
$A = \frac{q \ln \theta_A/\theta_B}{U(\theta_A - \theta_B)}$			A
$t_B = t_A - e(t_A - t_1)$		$t_B = t_A - \frac{e}{Nf}(t_A - t_1)$	t_B
$t_2 = t_1 + eNf(t_A - t_1)$	$t_2 = t_1 + e(t_A - t_1)$		t_2
$X_c = \frac{1 - eNf}{1 - e}$	$Y_c = 1$	$Z_c = \frac{1 - e/Nf}{1 - e}$	X, Y, & Z
$n = \frac{AU(1-Nf)}{W_h C_h}$	$n = 0$	$n = \frac{AU(1-1/Nf)}{W_c C_c}$	n
$t_m = \frac{e(t_A - t_1)(1-Nf)}{\ln X_c}$	$t_m = (t_A - t_1)(1-e)$	$t_m = \frac{e(t_A - t_1)(1-1/Nf)}{\ln Z_c}$	t_m
$A = \frac{W_h C_h}{U(1-Nf)} \ln X_c$	$A = \frac{W_c}{U}\left(\frac{e}{1-e}\right)$	$A = \frac{W_c C_c}{U(1-1/Nf)} \ln Z_c$	A
$e = \frac{1 - e^{n}}{Nf - e^{n}}$	$e = \frac{AU/W_c}{1 + AU/W_c}$	$e = \frac{e^{n} - 1}{e^{n} - 1/Nf}$	e
$t_B = t_A - (t_A - t_1)\left(\frac{1 - e^{n}}{Nf - e^{n}}\right)$	$t_B = t_A - (t_A - t_1)\frac{AU/W_c}{1 + AU/W_c}$	$t_B = t_A - (t_A - t_1)\frac{e^{n} - 1}{Nfe^{n} - 1}$ $= t_A - \frac{t_2 - t_1}{Nf}$	t_B
$t_2 = t_1 + (t_A - t_1)\frac{Nf(1 - e^{n})}{Nf - e^{n}}$ $= t_1 + Nf(t_A - t_B)$	$t_2 = t_1 + (t_A - t_1)\frac{AU/W_c}{1 + AU/W_c}$ $= t_1 + e(t_A - t_B)$	$t_2 = t_1 + (t_A - t_1)\frac{e^{n} - 1}{e^{n} - 1/Nf}$	t_2
$\theta = (t_A - t_1)\frac{Nf - 1}{Nf - e^{n}}$	$\theta = (t_A - t_1)\frac{W_c - AU}{AU + W_c}$	$\theta = (t_A - t_1)\frac{e^{n}(Nf - 1)}{Nfe^{n} - 1}$	θ

Table 2b. Operating Equations for Heat Transfer in Engineering Apparatus. COUNTER FLOW. (See Table 2a, preceding page, for PARRALLEL FLOW.)

finery, natural gasoline, and petrochemical plants. Specially designed heat exchangers are sometimes better for a particular job than a standardized unit but the initial cost is greater. Hence, as in other phases of heat transfer equipment selection, the economics of the installation must be studied before a decision can be made.

In the field of standardized shells, one and two pass units are most popular at present. Single, cross-baffled shell passes are also used frequently. These units are suitable for liquid heating, cooling, and condensing duties. Two pass shells with a longitudinal baffle are often applied where it is desired to reduce the number of shells used. Reduction of shell number cuts maintenance costs but the greater pressure loss through the exchanger may increase operating costs slightly.

Straight and "U" tube arrangements are the most frequently used. The "U" shape is the simplest because the bend absorbs expansion and eliminates need for a floating head and an internal gasketed joint. Straight tubes are either fitted with a floating tube sheet at the return end to absorb expansion or the tubes may be bent slightly near the middle. When a floating head is used it must be carefully selected so that it is perfectly suitable.

There is a total of about a dozen standard designs for heat exchanger heads. Stationary heads with various arrangements for head and tube sheet flanging permit use of different materials for flange and tube sheet, eliminate gasketed joints between channel and tube sheet, and are equipped with sealing plates. Dished and billet floating heads permit withdrawal of the tube bundle without dismantling the floating end and can be obtained with seal plates which eliminate the need for stay bolts.

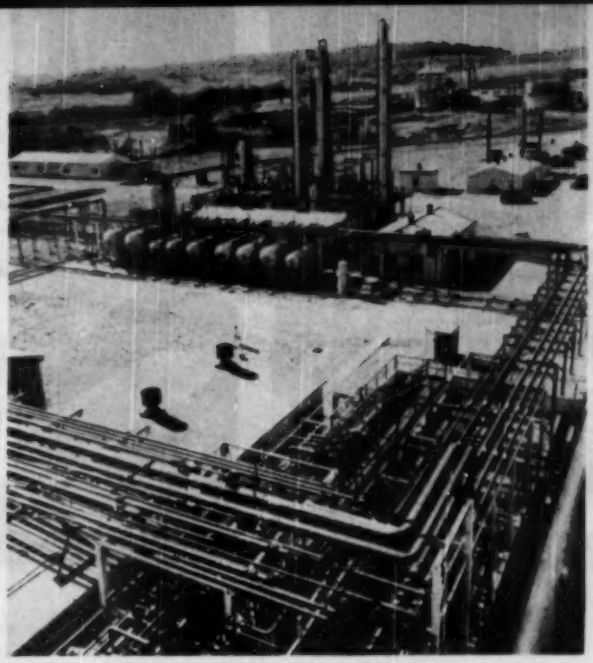
It is not the purpose of this article to recommend particular heat exchanger arrangements for refinery, natural gasoline, or petro-chemical plants. However, it is worthwhile for the plant designer to know that many arrangements do exist. Frequently space can be saved by utilizing a two pass exchanger instead of a single pass unit. Expensive expansion difficulties are avoidable by use of "U" tube exchangers or those equipped with floating heads. The refinery designer who is familiar with the many arrangements of heat exchangers available usually has fewer interference problems than the man whose knowledge is limited.

Typical economy equations and problems will be discussed in the succeeding and final part of this article.

(End of Part II. Part III will appear in an early issue.)

SYMBOLS

- A = total surface in contact with either fluid, in square feet
- c_c = mean specific heat of the cold fluid
- c_h = mean specific heat of the hot fluid
- H = heat lost to atmosphere, Btu/hr
- H' = heat gained from atmosphere, Btu/hr
- q = quantity of heat transmitted per unit time from the hot fluid to the cold one, Btu/hr
- r_c = $W_h C_h / W_c C_c$ = the fluid ratio
- t_A = temperature of the hot fluid entering the apparatus, °F.
- t_B = temperature of the hot fluid leaving the apparatus, °F.
- t_1 = temperature of the cold fluid entering the apparatus, °F.
- t_2 = temperature of the cold fluid leaving the apparatus, °F.
- U = thermal transmittance, or over-all coefficient of heat transmission, Btu/hr/°F./square feet
- W_c = weight of cold fluid flowing per unit time, lb/hr
- W_h = weight of hot fluid flowing per unit time, lb/hr
- θ = temperature difference at any point, °F.
- θ_A = difference in temperature of entering hot fluid and the surrounding cold fluid
- θ_B = difference in temperature of leaving hot fluid and the surrounding cold fluid
- t_m = mean temperature difference between the two fluids while passing through the apparatus
- e = 2.71828



Maze of Pipe Manifolding Links Distillation Area, Background, with Converters and Control House of Bureau of Mines Coal Hydrogenation Demonstration Plant at Louisiana, Mo. All illustrations used in this article are Bureau of Mines photos.

SYNTHETIC LIQUID FUELS

Status of Development in the U. S.

HAROLD A. STILES
Petroleum Engineer, Fuels and Lubricants Section, Research and Development Branch, Office of the Quartermaster General

THE 78th Congress passed Public Law 290 on April 5, 1944, expanding synthetic fuels research and development in the interests of economic and military security. This legislation directed the Bureau of Mines of the Department of the Interior to "conduct laboratory research and development work, and with pilot plants and semi-works plants to make careful process engineering studies along with structural engineering studies in order to ascertain lowest investment and operating costs, necessary to determine the best demonstration plant designs and conditions of operation." Originally established on a five-year basis, the program later was extended to eight years and the total authorized expenditure was increased to $60 million. With all laboratories now active and construction of the last demonstration plant recently completed, the work is entering its most valuable and fruitful phase.

As the supplier of liquid fuels and lubricants for Army uses, the Quartermaster Corps has a responsible interest in their development as a possible supplementary or substitute source of supply in the event the petroleum supply is inadequate. Considerable research and development work has been under way in this field, both by government agencies and by industry, and the part played by the Quartermaster Corps in furthering this development has been appreciable.

The status of work at each of the government plants is described by the author.

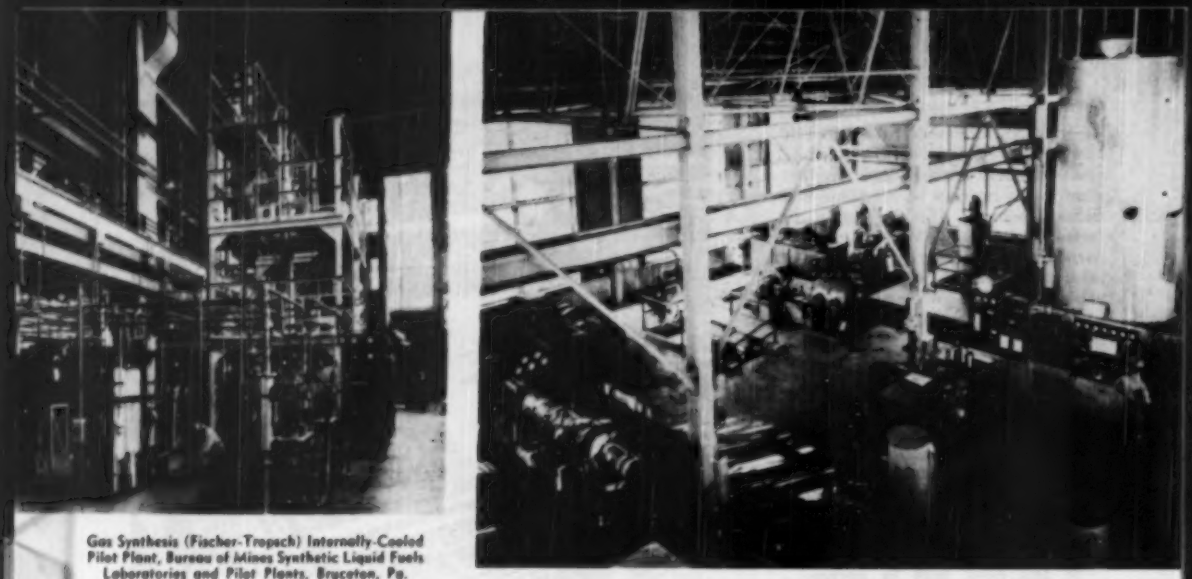
Operating through a newly created Office of Synthetic Liquid Fuels, under the direction of Dr. W. C. Schroeder, the Bureau of Mines has channeled its investigations into three major fields of synthetic development: i.e., coal hydrogenation, gas synthesis, and shale-oil production.

The petroleum industry also has been active with gas synthesis process developments using natural gas and coal as raw materials, and a limited amount of study in the field of shale-oil production. The program of the Bureau of Mines is based upon cooperation with industry, all steps being coordinated through an industry advisory committee. Thus the Bureau and industry are supplementing each other's efforts. Industry's developments have included laboratory and pilot plant investigations, and in one instance, the construction of a commercial-size plant to convert natural gas to liquid fuels. Unquestionably, the interest of industry in the development of synthetic liquid fuels has been stimulated by the work of the Bureau of Mines.

Progress of Development

The Office of Synthetic Liquid Fuels in its investigation early reviewed the work done by the Germans, this in order to take advantage of their developments and avoid duplication. This investigation included: 1) a study by Bureau personnel of synthetic plants in Germany and other foreign countries, including interviews with outstanding foreign scientists; 2) sending teams of U. S. scientists to inspect the German plants, interview scientists, and obtain captured reports and files; 3) a review of these documents by industry and Bureau personnel, acting under assignment by the API in translating and abstracting. German scientists brought to this country by the office of The Quartermaster General also gave assistance.

The Bureau has established facilities and organization to carry out the work as follow: 1) the Coal-to-Oil Demonstration Plants at Louisiana, Mo., for coal hydrogenation and Fischer-Tropsch synthesis developments on a semi-commercial plant scale; 2) research and development laboratories at Bruceton, Pa., for laboratory and pilot plant research on coal-to-oil processes; 3) synthesis-gas laboratories and pilot plants at Morgantown, W. Va., and Gorgas, Ala., for research in synthesis gas production and underground coal gasification



Gas Synthesis (Fischer-Tropsch) Internally-Cooled Pilot Plant, Bureau of Mines Synthetic Liquid Fuels Laboratories and Pilot Plants, Bruceton, Pa.

Oxygen is produced here, above, for use in gasifying coal at the Louisiana, Mo. plant. Air is liquefied at temperatures more than 300° below zero Fahrenheit and the nitrogen is removed, leaving high-purity oxygen.

work; 4) the oil-shale demonstration plant and experimental mines at Rifle, Colo., for semi-commercial-scale mining, retorting and refining of shale oil, and 5) the petroleum and oil shale experiment station at Laramie, Wyo., for research in oil-shale retorting and shale-oil refining. The facilities at Bruceton, Morgantown, and Laramie are mainly for the purpose of supplying basic information for the demonstration plants at Louisiana and Rifle. Only the development of these two will be outlined as they constitute the Bureau's "proving" facilities.

Coal-to-Oil Demonstration Plants, Louisiana, Mo.—During World War II, the Army built a $17 million anhydrous ammonia plant here, which at the end of the war was shut down and put on a "standby" basis. Upon request of the Secretary of the Interior the plant was assigned to the Quartermaster General, as custodian, for use by the Bureau of Mines in the development of synthetic liquid fuels.

These facilities, while basically meeting the new needs, required some modifications and additions which now have been completed. Preliminary "break-in" runs have been made, products from these runs are being tested by the Military Services, and it is anticipated that products from full scale operation will be available for Military testing shortly. Plant capacity is 300 to 400 barrels of liquid fuels per day, and will vary slightly, depending upon the products made and the type of coal used as raw material. Products will include aviation gasoline base stock, motor gasoline, jet fuel, diesel fuel, and several grades of burner fuel. The cost of these products from coal will be only slightly higher than similar products from petroleum, according to Bureau of Mines estimates, and, in some respects, will have superior properties to those derived from petroleum.

The Fischer-Tropsch or gas synthesis demonstration plant, scheduled for 1950 completion, also will use coal as the raw material and will have a capacity of 80 to 100 barrels per day of liquid products. Properties of the motor gasoline, high-octane diesel fuel and fuel oil produced will be somewhat different from petroleum products and from those obtained in coal hydrogenation. The costs should be reasonably in line with those from coal hydrogenation.

The technical staff of the Office of Synthetic Liquid Fuels, in cooperation with engineering design firms, has drawn up engineering designs and calculations for commercial-size plants of several capacities for both coal hydrogenation and Fischer-Tropsch processes. These research and development data will be available to industry.

Oil-Shale Demonstration Plant, Rifle, Colo.—Exploitation of oil shale involves developments in three major phases if liquid fuels of satisfactory quality are to be produced economically: 1) low-cost mining methods, 2) retorting procedures, and 3) refining techniques. Development work in all three is being vigorously prosecuted at Rifle and much has been accomplished by its research.

Perhaps the most progress made by the Bureau has been in the mining phase. With the oil content of the shale varying from 30 to 70 gallons per ton, commercial operation on a very large scale would be required for an appreciable volume of oil. Consequently, the Bureau's mining program has been directed toward low-cost, large-scale mining methods, including development of special mining machinery. Results have been very encouraging, and the Bureau has demonstrated that oil shale can be mined at a total cost of less than 60 cents per ton. The Bureau is continuing research in this field and will, no doubt, further reduce these costs.

The Bureau's procedure in the development of retorting methods has been first to construct a semi-commercial-size unit of known design and proven worth to provide shale oil for refining research, while at the same time seeking a better retorting process through laboratory and small pilot plant study. The unit so constructed had been developed and used in years past, to a limited degree, and it was known that it would provide the necessary oil and also furnish basic data on which to design improvements. This unit, in operation for some time, has produced an appreciable quantity of shale oil for further processing. An attempt to find a continuous process for retorting the shale at costs competitive with other sources of liquid fuels has resulted in the development of a promising unit known as the gas-flow retort. Latest estimates indicate a cost of less than 90 cents per barrel of oil for shale retorting. This would result in actual production cost of $1.50 per barrel for crude shale oil.

The lack of a satisfactory refining

technique for shale oil has long been a stumbling block. Shale oil, as produced by known retorting methods, is a heavy, low grade product (by petroleum standards) containing large quantities of such undesirable materials as sulfur, nitrogen, etc. An economical method of removing these contaminants and converting the crude shale oil to desirable products comparable with similar products from petroleum has long been sought, but as yet has not been completely solved. However, it has been found that a mild hydrogenation of shale-oil fractions will reduce the sulfur and nitrogen, upgrade the products, and increase the yields. Further, it is possible to combine thermal refining and hydrogenation. By cracking to coke and mildly hydrogenating the coker distillate, good quality gasoline, diesel fuels, and domestic heating oils may be made. Improved processes are being sought through research.

The Rifle demonstration plant has been assisted greatly in its development work by the Experiment Station in Laramie, Wyo. This station has made the necessary fundamental studies in retorting and refining which have been the basis for plant design at Rifle. A shale-oil refining and treating unit of approximately 200 barrels per day capacity was designed and constructed at Rifle with the assistance of information developed in the Laramie laboratories. This unit, in operation for several months, has produced a variety of products for experimental purposes. The Military is now testing several of these products, notably, heavy fuel oil, gasoline, and diesel fuel, to evaluate their special properties.

In its development work on retorting and refining, the Bureau has been assisted by and has coordinated its activities with Standard Oil Development Company, Socony-Vacuum Oil Company, and Union Oil Company. The latter company, in particular, has carried on extensive research, the result of which has been development of very promising methods of retorting and refining which should, together with methods being explored by the Bureau, ultimately result in methods necessary to the success of an oil-shale industry. The Bureau is now producing at its Pittsburgh laboratories a quantity of jet and diesel fuels for Military testing, using a refining procedure developed by Union Oil Company. This company also furnished the catalyst for this operation, and trained Bureau operators. This is a good example of the cooperation between the Bureau of Mines and industry in synthetics research.

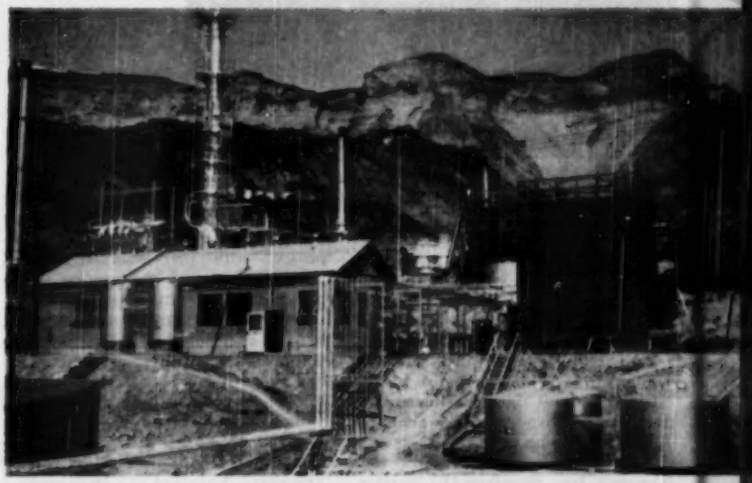
Progress of Development — Industry

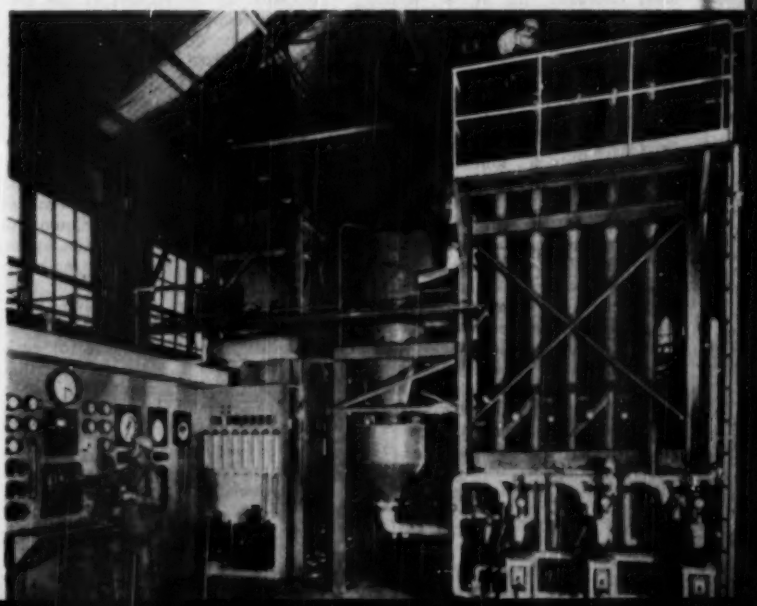
As related, industry has done a great deal of research in synthetic liquid fuels and has contributed substantially to developments. Its interest, like that of the Bureau of Mines, was stimulated by the accomplishments in Germany, and it has made full use of German technique and German scientists in its work since the end of World War II. In general, industry has favored developments in the gas synthesis field rather than coal hydrogenation or oil shale as it believes that this process offers the most promising method of synthetic liquid fuels production.

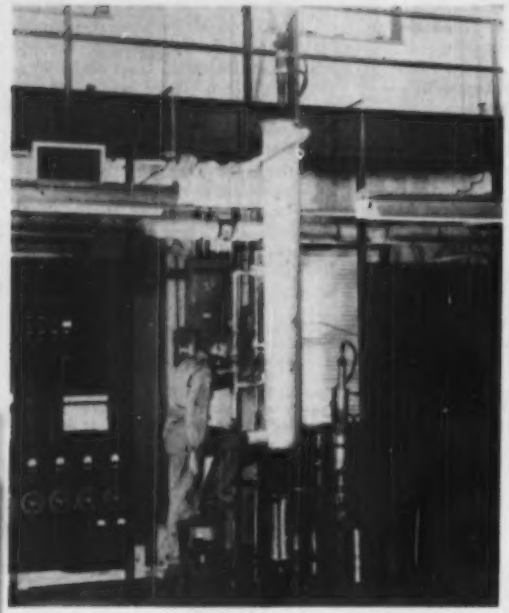
Perhaps the leaders in gas synthesis developments, at the present time, are the Texas Company and Hydrocarbon Research, Inc. Their development, the Hydrocol process, is a modified Fischer-Tropsch process for convert-

Top photo—Experimental Shale-Oil Refinery near Rifle, Colo. This Bureau of Mines unit is capable of all the usual thermal operations, including viscosity breaking, recycle and once-through cracking, reforming, atmospheric distillation, and coking. It includes a cold-acid treating plant.

Lower photo—Gas Flow retort, a Continuous Pilot Plant for Extracting Oil from Shale at the Rifle, Colo., plant. Shale moving downward through the square structure beyond the control board is heated by a transverse flow of hot gases. Oil is recovered in the condensing system at right.







Temperatures up to 1500° F. can be attained through the use of radiant heat in this bench-scale retort at the Petroleum and Oil-Shale Experiment Station of the Bureau of Mines at Laramie, Wyo. It is being used to determine the possibilities of obtaining very rapid conversion of oil-shale kerogen to oil—a conversion that, at these temperatures, should occur in seconds rather than the several hours required in most large-scale retorts. This and other photos in this article by Bureau of Mines.

ing either natural gas or coal to liquid fuels. Carthage Hydrocol, Inc.'s Brownsville, Texas, plant uses this process and will be operating this year. Natural gas will be the raw material and it will have a capacity to produce 6000 barrels of gasoline and 1100 barrels of other fuels per day. The government has an indirect interest in this plant since the Reconstruction Finance Corporation has advanced approximately half the cost.

The Texas Company, Hydrocarbon Research, Inc., Standard Oil Development Company, the M. W. Kellogg Company, Koppers Company, and others are continuing their laboratory and pilot plant research in gas synthesis.

Standard Oil Development Company, in conjunction with Pittsburgh Consolidated Coal Company, has carried on research in a "fluidized" process for converting coal to liquid fuels. It is reported that Kellogg, in conjunction with Cities Service Oil Company, has developed its own modification of the Fischer-Tropsch process and has indicated that it is prepared to license its process for commercial operation, as is the Texas Company. Koppers Company, having the benefits of the developments of its parent company in Germany, is under contract to the Bureau of Mines to jointly develop procedures and construct the gas synthesis plant for the Bureau of Louisiana, Mo. Improvements are continually being made in the gas synthesis process. Using natural gas as the raw material, the process is reported competitive with petroleum at present prices. Using coal, the process is approaching competitive status.

Several companies, as mentioned, have shown interest in oil-shale development. In addition, several others have acquired oil shale holdings, but have conducted little or no research. It is understood that Kellogg has a program for research in shale-oil refining, but has no interest in retorting procedure. Standard Oil Development Company, at the request of the Bureau, has conducted large pilot plant investigations in processing oil shale by the "fluidized" process. This work was carried out at Baton Rouge, La., using oil shale prepared and furnished by the Bureau.

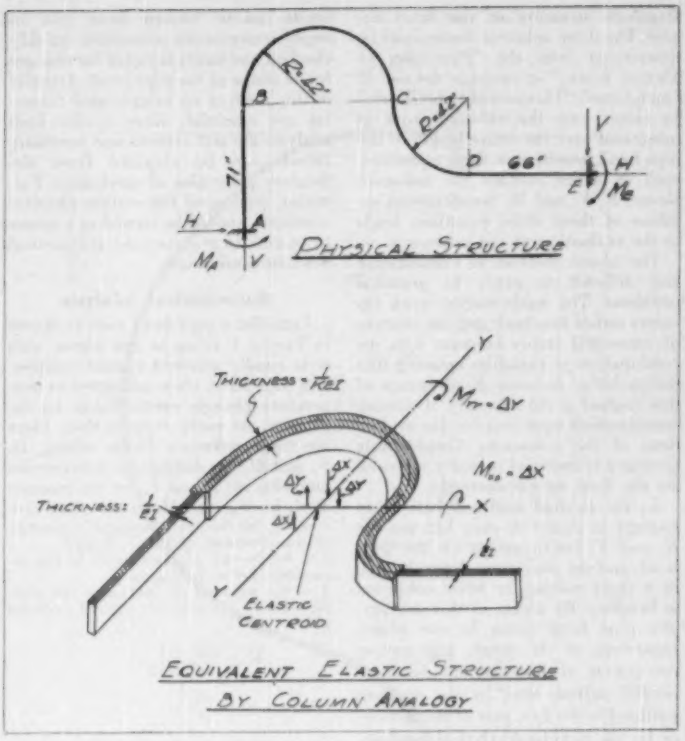
The Bureau also has conducted both laboratory and field-scale experiments in underground gasification of coal. In field experiments, it has been assisted by Alabama Power Company. Assistance also has been given by an industry advisory committee made up of representatives of the major coal mining and coal processing industries. The object here is to determine the feasibility of and procedure for gasification of coal in place, in order that utilization might be made of thin beds of coal not profitable to mine. The resulting gas would be synthesized or used for fuel as such. The experiments, promising but inconclusive so far, will be continued.

Until recently, many have felt that the coal hydrogenation process could never compete with gas synthesis in the production of synthetic liquid fuels. Late cost estimates, however, support the Bureau's contention that coal hydrogenation and gas synthesis are substantially equal on a cost basis. Products of the two processes are entirely different, and the Bureau maintains that the processes should complement rather than compete with each other. It is significant that a large American chemical corporation is said to be building a coal hydrogenation plant at a reported cost of $8 to 10 million to produce chemicals as the primary products and gasoline and oil as by-products.

Some have said that the Bureau's program is on a scale larger than necessary to obtain required answers. In reply, the Bureau states that the prime function of its demonstration plants is to apply the results of laboratory research and development on a scale that will translate those results into information useful to any private interests planning commercial production. Actually, the largest of the Bureau's demonstration plants has a capacity of only 200 to 300 barrels daily, whereas the capacity of a minimum-size commercial operation would range from 5000 to 10,000 barrels daily. The Synthetic Liquid Fuels Act (Public Law 290—78th Congress) stipulates that "the plants shall be of minimum size which will allow the government to furnish industry the necessary cost and engineering data . . . and that the combined product of all the plans constructed . . . will not constitute a commercially significant amount of the total national commercial sale and distribution of petroleum and petroleum products." This restriction has been closely observed.

As the Bureau has pointed out, many of the laboratory and pilot-plant data it develops can be proved to advantage in an intermediate-size unit before private industry builds a commercial-scale plant, for there are definite minimum operable sizes for much synthetic-fuels equipment below which little commercially useful information could be obtained. Then, too, it has been necessary to acquaint equipment manufacturers with the problems incident to the special high-pressure and temperature equipment required for synthetic-fuel plants, and this could be done only on sizes approaching those being used. The writer believes the Bureau's reasoning to be sound, and that the information being obtained eventually will prove of great value in the development of a synthetic liquid fuels industry in this country.

FIGURE 1



Forces in Pipe Bends From Expansions

F. E. WOLOSEWICK, Structural Engineer, Chicago

THE primary function of pipes is to convey vapors or liquids from one point to another, under various temperature and pressure conditions. Into these lines are incorporated various mechanical and safety appliances, such as control valves, check valves and safety valves, which assist in the operation and control of the process. Under certain conditions of thermal expansion and restraint of varying degree,

IT IS NOT an uncommon sight around oil refineries and other process plants to see nozzles deflected, flange connections leaking, tight anchors distorted, or sheared, safety valves bent, and pump blocks displaced. Under such misalignment of mechanical and control equipment, leakages result and the operation of the unit is not as smooth or safe as desired.

The expansion of the various lines set up considerable forces which must be provided for, either by suitable anchorages, or other resisting structures. These structures must be designed to withstand the forces placed on them and also to localize their actions between definite points so as not to endanger or distort any important mechanical equipment.

these lines develop forces which can be of sufficient magnitude to distort the lines, and affect the operation of the equipment attached to them.

In view of the constantly increasing trend toward larger units and toward larger piping at higher temperatures and pressures, it is necessary to treat pipe bends as an important structural problem. The same thought and foresight which is applied to the design of major structures should also be given to the layout of pipe bends. This article considers many of the factors affecting these problems and illustrates the practical design of typical pipe bends.

Actually the design of the pipe bends is somewhat more complex than the design of the ordinary structure, because of the presence of various uncertain elements. Thus the pipe in addition to carrying internal pressure, is also subjected to creep, erosion, corrosion, vibration, gravity loading, wind, and temperature variation. Because of the complexity of the problem, a majority of the various items do not lend themselves to suitable mathematical analysis.

A method of analysis is suggested herein which can be applied with a modicum of effort to any single plane pipe bend having two points of anchorage. It may also be applied to a bend lying in space and having two points of anchorage. The underlying principles upon which this analysis is based, were first formulated by Professor Cross, and have been summarized and published in Bulletin No. 215 by University of Illinois, entitled "Column Analogy."

Forces Acting on Pipe Bends

When a pipe bend lying in a plane and restrained at both ends is subjected to temperature changes, there will be developed three unknown forces at each end, namely, a horizontal force H, a vertical force V, and a moment M. If the pipe bend has an axis of symmetry, then all the forces at both ends are equal. Whenever dissymmetry occurs, the H, and the V are, equal, but the moments at both ends are different, in order to preserve statical equilibrium.

A pipe bend which is subjected to the conditions of restraint at both ends may be considered as a statically inde-

terminate structure of the third degree. The three unknown forces may be determined from the "Principles of Virtual Work," or through the use of Castigliano's "Theorem of Least Work." In either case the external work is integrated over the entire length of the pipe bend, resulting in three equations, each of which contain the unknown forces, H, V, and M. Simultaneous solution of these three equations leads to the evaluation of the unknowns.

The above method is cumbersome and difficult to apply to practical problems. The mathematical work becomes rather involved, and the chances of numerical errors increase with the combination of variables entering into the problem. Another disadvantage of this method is the necessity of solving simultaneous equations for the evaluations of the unknowns. Considerable accuracy is essential in order to evaluate the final results correctly.

In the method outlined herein, an analogy is shown to exist between the H, and V forces acting on the pipe bend, and the unit stress determination in a short column or beam subjected to bending. By means of this analogy, any pipe bend lying in one plane, regardless of its shape, and having two points of restraint can be more readily solved, than by the methods outlined in the first part of this article, or by the Grapho-Analytical methods.

Some of the advantages of this method are that the analysis of pipe bends can be broken down into an easily remembered procedure, quickly checked, and easily adjusted for changes in the shape of the pipe bend. Actually in this method no complicated formulas are essential, since in the final analysis the self evident and necessary factors can be obtained from elementary principles of mechanics. Formulas, developed for certain physical constants, should be viewed as a means to an end, in reducing the arithmetical work to a minimum.

Mathematical Analysis

Consider a pipe bend such as shown in Figure 1, lying in one plane, with ends rigidly attached against rotation. The pipe bend when subjected to temperature change, exerts forces on the support. At every support then, there are three unknown forces acting, H, V, and M. To distinguish between the moments at A, and B, let the moment at A, be M_A, and M_B at the other end.

Let Δx, be the net horizontal expansion in the direction of the X-X axis.

Let Δy, be the net expansion in the direction of the Y-Y axis.

I, is the moment of Inertia of the pipe.

K, rigidity constant for curved portions only;

$$K = \frac{12h^2 + 1}{12h^2 + 10};$$

Where $h = \frac{tR}{r^2}$;

t = thickness of pipe wall in inches

R = radius of bend, inches

r = mean radius of pipe, inches

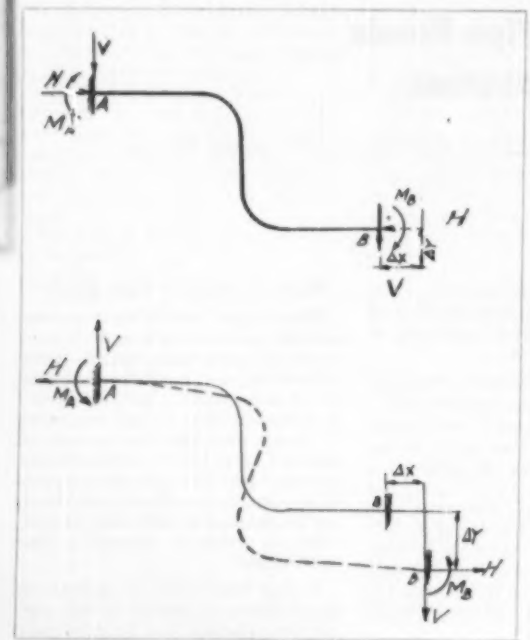


FIGURE 2

E = Young's Modulus of Elasticity, at the temperature of the pipe.

By means of Castigliano's theorem, the total external work in the pipe bend can be expressed as follows:

$$W = \int_A^B \frac{M^2 ds}{2KEI} \qquad (1)$$

M, is the bending moment at any section, expressed in terms of the unknown forces at A. Obviously the bending moment varies from section to section, and in turn must be modified by rigidity constant K, when the integration is extended around the curved portions of the bend. For any point, such as z, the bending moment becomes:

$$M = M_A + Vx - Hy \qquad (2)$$

Substituting in equation (1), the work is then expressed as

$$W = \int_A^B (M_A + Vx - Hy)^2 \frac{ds}{2KEI} \qquad (3)$$

By means of Castigliano's First theorem, the partial differential quotients of strain energy, with respect to the unknown forces H, and V, will be equal to the deflection in the direction of these forces. Also the partial differential quotient of strain energy, with respect to the unknown moment M_A, will give the angular change at the support A.

In the problem under consideration, it is assumed that, the angle changes at the supports are equal to zero. That is to say, that the tangent to the elastic line, at the supports cannot rotate. This physical condition of the terminal, is sometimes called a fixed joint, and the structure as "fixed ended."

Differentiating equation (3) partially with respect to the unknown forces, and equating the differential quotients to the deflections in the direction of these forces, and to zero for the condition of zero angular change, the following three general equations are obtained:

$$\frac{\partial W}{\partial H} = \Delta x = \int (M_A - Hy + Vx)(-y)\frac{ds}{KEI} \qquad (4)$$

$$\frac{\partial W}{\partial V} = \Delta y = \int (M_A - Hy + Vx)(x)\frac{ds}{KEI} \qquad (5)$$

$$\frac{\partial W}{\partial M_A} = 0 = \int (M_A - Hy + Vx)(1)\frac{ds}{KEI} \qquad (6)$$

Expanding the above equations, and carrying through the multiplications as indicated, these equations become:

$$\Delta x = -\int M_A \frac{y\,ds}{KEI} + \int \frac{Hy^2 ds}{KEI} - \int \frac{Vxy\,ds}{KEI} \quad (7)$$

$$\Delta y = \int M_A \frac{x\,ds}{KEI} - \int \frac{Hxy\,ds}{KEI} + \int \frac{Vx^2 ds}{KEI} \quad (8)$$

$$0 = \int M_A \frac{ds}{KEI} - \int \frac{Hy\,ds}{KEI} + \int \frac{Vx\,ds}{KEI} \quad (9)$$

It will be noticed that the origin was taken at the left end of the pipe bend. Now assume that the origin was moved from point *A* to some other point *O*, such that the following integrals will become equal to zero:

$$\int \frac{y\,ds}{KEI} = 0, \text{ and } \int \frac{x\,ds}{KEI} = 0$$

These two integrals may be considered as statical moments of ds/KEI. In order that they may satisfy the above condition the neutral axis must pass through the centroid of the section. Hence point *O* then becomes the center of gravity of the whole pipe bend, and equations (7), (8), and (9), take on a simpler form. In order to make these equations perfectly general, it must be understood that the integration must be extended, to the left, and to the right of point *O*, in order to cover the whole pipe. Simplifying the above equations,

$$\Delta x = H\int \frac{y^2 ds}{KEI} - V\int \frac{xy\,ds}{KEI} \quad (10)$$

$$\Delta y = -H\int \frac{xy\,ds}{KEI} + V\int \frac{x^2 ds}{KEI} \quad (11)$$

$$0 = M_A \int \frac{ds}{KEI} \quad (12)$$

From the above equations the unknown values of *H*, and *V*, can be evaluated as follows: multiply equation (10) by $\int \frac{x^2 ds}{KEI}$, and equation (11) by $\int \frac{xy\,ds}{KEI}$ and then adding these two equations together, the unknown force *H* can be determined. Hence,

$$H = \frac{\Delta x \int \frac{x^2 ds}{KEI} + \Delta y \int \frac{xy\,ds}{KEI}}{\int \frac{y^2 ds}{KEI}\int \frac{x^2 ds}{KEI} - \int \frac{xy\,ds}{KEI}\int \frac{xy\,ds}{KEI}} \quad (13)$$

In similar manner *V* is evaluated and is equal to:

$$V = \frac{\Delta x \int \frac{xy\,ds}{KEI} + \Delta y \int \frac{y^2 ds}{KEI}}{\int \frac{y^2 ds}{KEI}\int \frac{x^2 ds}{KEI} - \int \frac{xy\,ds}{KEI}\int \frac{xy\,ds}{KEI}} \quad (14)$$

Equations (12) and (14) may also be developed from consideration of unsymmetrical bending of short columns.[1] Then through the use of the relationship between the deflections, and angle changes, as will be explained later, equations identical in form to the above may be obtained.

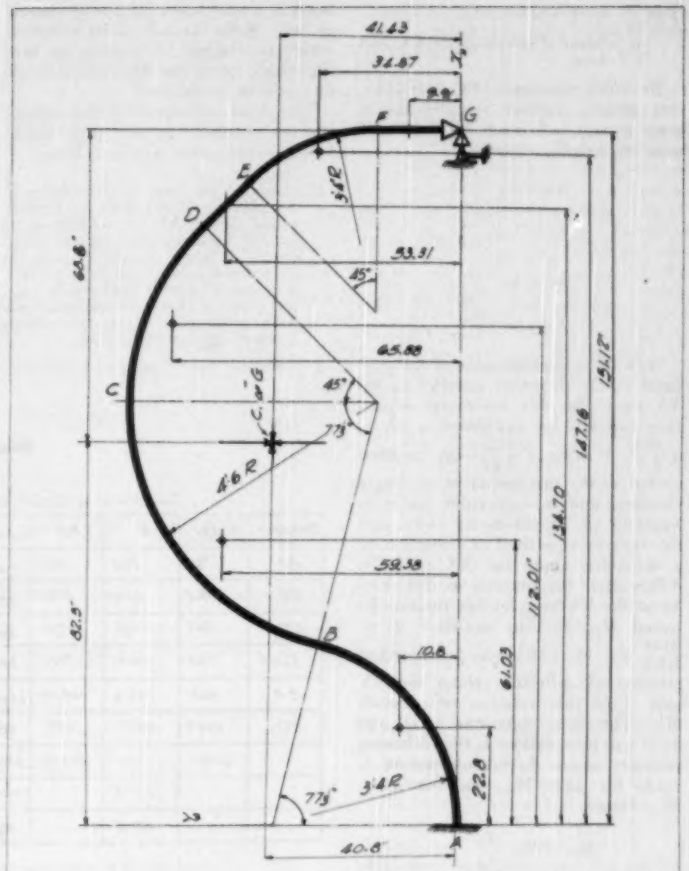


FIGURE 3

The Analogy

Consider the pipe to have an elastic thickness equal to 1/KEI, for curved members, and 1/EI for straight segments of the pipe bend, then the following elastic properties are self evident.

That, $\frac{1\,ds}{KEI} = dA$, and $\frac{1\,ds}{EI} = dA$;

$\int \frac{y^2 ds}{KEI} = \int y^2 dA = I_{xx}$,
or moment of inertia about XX axis.

$\int \frac{x^2 ds}{KEI} = \int x^2 dA = I_{yy}$,
or moment of inertia about YY axis, through the centroid of pipe bend.

$\int \frac{xyds}{KEI} = \int xydA = I_{xy}$,

or product of inertia about XX, and YY axes.

Rewriting equations (13), and (14), and making further symplifications, these equations become, for a pair of axes through the centroid:

$$H = \frac{\Delta x + \Delta y \frac{I_{xy}}{I_{yy}}}{I_{xx} - I_{xy} \frac{I_{xy}}{I_{yy}}} \quad (15)$$

$$V = \frac{\Delta y + \Delta x \frac{I_{xy}}{I_{xx}}}{I_{yy} - I_{xy} \frac{I_{xy}}{I_{xx}}} \quad (16)$$

Now Δx is the expansion of the pipe bend in the direction parallel to the XX axes. But this horizontal expansion can also be expressed as $\Delta x = \int \frac{Mds}{KEI} y$, where $\int \frac{Mds}{KEI}$ can be interpreted as the summation of all angle changes, due to expansion, or it is equal to $\int \theta$. Therefore $\Delta x = \theta y$, and this may be visualized as a rotation or a deflection about the XX axis. To differentiate the rotation of deflection about the XX axis, let this rotation be called M_{xx}. In like manner $\Delta y = \frac{Mds}{KEI} x = \theta x$, which may be viewed as rotation of deflection about the YY axis. Call this rotation or moment M_{yy}. Therefore equations (15) and (16) can be rewritten in the following manner, where direct substitution is made for $\Delta x = M_{xx}$, and for $\Delta y = M_{yy}$. Hence,

$$H = \frac{M_{xx} + M_{yy} \frac{I_{xy}}{I_{yy}}}{I_{xx} - I_{xy} \frac{I_{xy}}{I_{yy}}} \quad (17)$$

$$V = \frac{M_{yy} + M_{xx} \frac{I_{xy}}{I_{xx}}}{I_{yy} - I_{xy} \frac{I_{xy}}{I_{xx}}} \quad (18)$$

If the pipe bend were visualized as placed on an elastic foundation, the deflections Δx and Δy, acting as moments about the XX, and YY axes respectively, then there is an exact analogy between the forces acting on the pipe bend, and the flexural bending of any unsymmetrical short column.

Whenever there is an axis of symmetry, the I_{xy} terms become equal to zero, and the equations (17) and (18) reduce to the simple forms as follows:

$$H = \frac{M_{xx}}{I_{xx}}, \text{ and } V = \frac{M_{yy}}{I_{yy}} \quad (19)$$

These two simple equations are now identical in form to the standard flexural formula, $f = M/I$, where f is the flexural stress intensity at a unit distance above or below the neutral axis of the section. Consequently then, the determination of reactions in a pipe bend, is analagous to the determination of unit stress in any short column, which is strained by couples in two directions, or to the determination of unit stresses in beams.[1]

The steps necessary for determination of reactions in any pipe bend, lying in one plane are as follows:

1) Consider the pipe bend to have a thickness equal to 1/KEI, for curved bends, and 1/EI for straight segments. Compute the elastic area, center of gravity with respect to some fixed point preferably, the left terminal. The term 1/EI can be factored out of these calculations, and used only once, when the actual force determination is made.

2) Compute the moments of inertias, and the product of inertia about the fixed point. Then correct to center of gravity of the pipe bend.

3) Determine the net horizontal and vertical displacements, and use either of the formulas, best suited for this type of a bend.

As in a majority of elastic problems, considerable work can be saved by using tabular form for all calculations. Once the centers of gravity are established for the various component parts of the pipe bend, the balance of problem becomes purely mechanical. The signs become automatically adjusted.

Through the use of the tabular form adjustments of the pipe bend to new

FIGURE 4

CASE X – LINE COLD – VESSEL AT 860°F – NET EXPANSION = 0.41"

SEGMENT	$A \cdot \frac{1}{KEI}$	$\bar{x}$	$A\bar{x}$	$I_{yy} + I_o \cdot A\bar{x}^2$	$\bar{y}$	$A\bar{y}$	$I_{xx} + I_o \cdot A\bar{y}^2$	$I_{xy} + I_o \cdot A_{xy}$
AB	72.5	22.8	1813	10300 41,400	12.8	859	5700 9290	8000 19,400
BC	94.2	61.03	5750	27,800 351,000	59.36	5600	12,500 332,000	16,400 341,000
CD	54.7	112.01	6130	6,800 690,000	63.88	3610	1200 238,000	-2840 405,000
DE	13.3	134.7	1793	69 242,000	53.31	710	69 37,900	-1130 99,700
EF	46.3	147.16	6820	3150 1,007,000	36.87	1620	360 54,400	-1300 238,000
FG	21.07	131.12	3175	0 481,000	9.91	208	770 2,070	0 31,800
	909.1		25,901	2,850,500		12,607	636,459	1,169,900
		82.5"		-2,100,000	40.8"		515,000	-1,040,000
		68.6"		750,500 KI	41.43		181,400 KI	129,900 KI

$H = \frac{0.41 \cdot 30 \cdot 10^6 \cdot 106}{181,400 - 129,900 \frac{82.5}{68.6}} = 7900\#$ $\qquad V = \frac{0.41 \cdot \frac{106}{144} \cdot 30 \cdot 10^6 \cdot 106}{750,500 - 129,900 \frac{82.5}{68.6}} = 1150\#$

$M_o = 41.43 \cdot 7900 - 1150 \cdot 68.62 = 0$ $\qquad -M_A = -1150 \cdot 82.5 + 7900 \cdot 40.8 = 0$

$M_o = 406,000"\#$ $\qquad M_A = 227,000"\#$

$\Sigma M_o = 0 \qquad 406,000 - 1150 \cdot 131.12 - 7900 \cdot 0.63 - 227,000 = 0$

$+ 401,200 - 401,000 \approx 0$

STRESS ANALYSIS

BOLTS ON DISCHARGE SIDE OF VALVE

8" BOLTS $S = 9.97 = 36.5$

$n = 12, \quad r = 6.03"$

$a = 0.42"$

$M = 406,000 - 7900 \cdot 10 = 322,000"\#$

$f = \frac{322,000}{36.5 \cdot 0.42} = 21,000\#/"$

ON 8" PIPE $\qquad f = \frac{322,000 \cdot 4.5}{106} = 13,700\#/"$

BOLTS ON 4" INLET SIDE OF VALVE

$n = 8 \qquad S = 15.35$

$r = 3.85"$

$M = 406,000 - 1150 \cdot 8.75 = 396,000\#"$

$f = \frac{396,000}{15.35 \cdot 0.42} = 61,500\#/"^*$

ON INLET NECK OF SAFETY VALVE

O.D. = 6" $\quad$ I.D. = $4\frac{3}{16}$" $\quad I = 34.6"^4$

$f = \frac{396,000 \cdot 3}{34.6} = 34,500\#/"^{**}$

ON 4" CAST STEEL FITTING:

O.D. = $5\frac{7}{8}$" $\quad$ I.D. = 4" $\quad I = 28.5$

$f = \frac{396,000 \cdot 2.68}{28.5} = 37,300\#/"^{**}$

* BOLT TEMPERATURE, ABOUT 350°F.

** TEMPERATURE OF FITTING, AND INLET OF VALVE ABOUT 800°F.

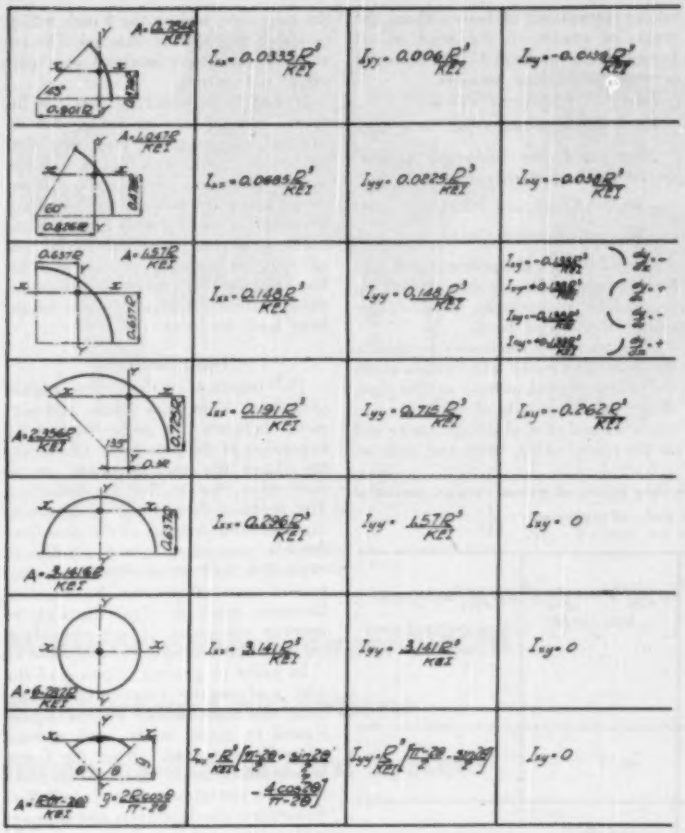


Figure 5a—Inertias of Sections through Centroid of Pipe Bends.
See notes presented with Figure 5b, next page.

dimensions can be made with the minimum amount of effort. Variations in moment of inertia of the pipe bend, and changes in modulus of Elasticity due to unequal heating of some segments, do not represent any additional work, as they may be entered as corrections to the values of E, and I used throughout the balance of the system.

The above analogy may be visualized as a convenient tool of analysis. Its usefulness is not limited only to the determination of reactions in pipe bends. In its fullest extent it may be used to evaluate the following: fixed moments, carry-over factors, determination of moments, and reactions when the pipe bend is subjected to variable restraints, or to vertical loadings lying in the plane of the bend and to the determination of deflections. It can also be easily adapted to the solutions of pipe bends having zero restraints at the ends. Because of the analogy to the simple flexure formulas, it offers a ready and a useful tool in analyzing pipe bend problems.

In order to establish mathematically the correct direction of the forces acting on the ends of the pipe bend, two distinct cases should be observed. In the first case, it will be assumed that the supports to which the pipe bend is attached do not yield. This condition is one most frequently occurring in practice, as for instance in the turbine expansion lines. Figure 2 will assist in illustration of the method.

With respect to point A, point B when released will have two degrees of freedom, ΔX horizontally and to the right ΔY vertically, and downwards. According to the established sign convention, all deflections to the right and up will be considered positive, those to the left, and downwards, negative. The direction of forces as computed will be shown in Figure 2. Since the support B is assumed as unyielding, the correct direction of the forces acting on point B must be opposite to those computed. Hence algebraically,

$H_B = 0 - H = -H$, or to the left.

$V_B = 0 - (-V) = +V$, or upwards.

The direction of forces at point A must be such as to preserve statical equilibrium, or opposite to those at B.

The second condition occurs when point B is actually displaced with respect to point A. The above condition would occur in a line connecting two points on a hot vessel, the line in this instance being cold. Then as before, ΔX, will be to the right, and positive, ΔY, downwards or negative. The forces H, and V as determined from analysis, will be correct in direction.

Illustrative Example

The unusual pipe bend layout shown in Figure 3 will be analyzed to bring out the application of the method, and also the possibility of high stress concentration occurring on a 4 x 6 safety valve. Directly below this safety valve is an extra heavy, 4 inch series 60 special cast steel fitting which connects to the side of the vessel.

It seemed reasonable at first that in view of the excessive amount of metal at point C, and shortness of the fitting below the safety valve, that a fixed point could be assumed on the vertical center line of the valve. Further studies have indicated, that the supposition was not much in error.

The pipe in the above example was an eight-inch, Schedule 80, with ½-inch wall thickness. The t/r^2 was evaluated at 0.0303, and the rigidity factors were computed for the different radii. The various elastic areas were computed, centers of gravity determined for the component parts with respect to point A. The next step is the evaluation of statical moments of elastic areas about two sets of rectangular axes passing through point A, and the determination of center of gravity of the whole pipe bend. The succeeding steps would be the evaluation of moments of inertias, and products of inertias, about point A, and then correcting them to the centroid of the section. This is accomplished through the use of standard formulas of elementary mechanics as follows:

$$I''_{xx} = I_{xx_A} - Ay^2$$

$$I''_{yy} = I_{yy_A} - Ax^2$$

$$I''_{xy} = I_{xy_A} - Axy.$$

In the above, the Io terms are the required moments of inertias of elastic areas through the center of gravity o of the pipe bend. I_{xx_A}, I_{yy_A}, and the

I_{xy_A} are the elastic properties about point *A*. It should be observed that term Io_{xy} can become either positive or negative, depending of course in which quadrant the pipe bend is located.

The vessel expands vertically pulling point *G* up 0.91 inch. Theoretical cold spring of one-half inch is permitted, making the net upward deflection of the bend equal to 0.91 — 0.5 = 0.41 inch. Next, the horizontal and vertical forces are computed, the values of H = 7900 pounds, and V = 1150. As point *G* moves away to the right from point *A*, the direction of the forces as determined are positive, thereby establishing their direction at point *G*. If however, the line was hot, and point *G* stationary, the direction of forces must be reversed.

Moments are next computed, by taking summation of forces about the center of gravity of the bend, of all forces acting on point *G*. The equation of equilibrium then becomes:

$$M_G - 1150 \times 68.62 - 7900 \times 41.43 = 0$$

M_G = 406,000 pound inches Clockwise.

Also at *A*, the following statical condition is apparent:

$$-M_A - 1150 \times 82.5 + 7900 \times 40.8 = 0$$

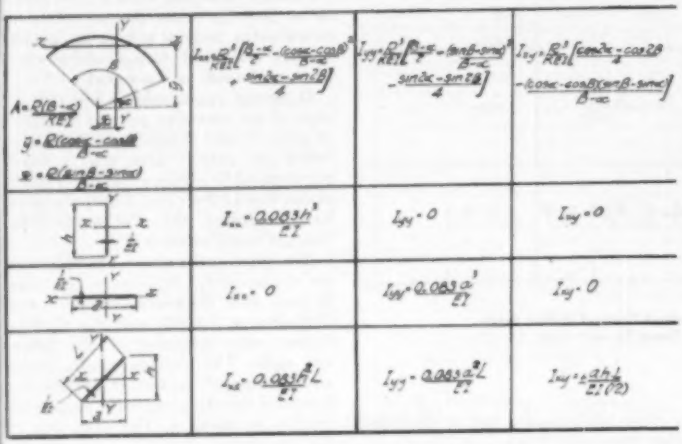
M_A = 227,000 pound inches.

A test for statical equilibrium should next be made. This is done by taking summation of moments of all forces acting of the pipe bend.

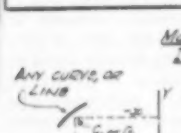
The next step in the analysis would be the determination of unit stresses at the following critical points: on the pipe, at the discharge side of the valve, on the bolts and neck at the discharge end of the safety valve, bolts and neck on the inlet side, and on the 4 inch fitting to which the valve is attached. The results of the above analysis are indicated in Figure 4.

It should be observed that the internal stresses are so large, due to unusual stiffness of the pipe bend, that permanent set would take place on the inlet side of the valve, or on fitting below the valve. Progressive application of these forces would eventually strain the valve completely out of line, or possibly rupture the fitting. During this process of straining, the operation of the safety valve would have been doubtful.

Figure 5b—Figures 5a (on previous page) and 5b show inertias of sections through centroid of pipe bend. All curves are arcs of circle, all thicknesses = $\frac{1}{KEI}$


A = Q(B − α) / KEI
ȳ = R(cosα − cosβ) / (β − α)
x̄ = Q(sinβ − sinα) / (β − α)
$I_{xx} = \frac{Q^3}{KEL}\left[\frac{\beta-\alpha}{2} - \frac{(\cos\alpha-\cos\beta)^2}{\beta-\alpha} + \frac{\sin 2\alpha - \sin 2\beta}{4}\right]$
$I_{yy} = \frac{Q^3}{KEL}\left[\frac{\beta-\alpha}{2} - \frac{(\sin\beta-\sin\alpha)^2}{\beta-\alpha} - \frac{\sin 2\alpha - \sin 2\beta}{4}\right]$
$I_{xy} = \frac{Q^3}{KEL}\left[\frac{\sin 2\alpha - \sin 2\beta}{4} - \frac{(\cos\alpha-\cos\beta)(\sin\beta-\sin\alpha)}{\beta-\alpha}\right]$
$I_{xx} = \frac{0.083h^3}{EI}$
$I_{yy} = 0$
$I_{xy} = 0$
$I_{xx} = 0$
$I_{yy} = \frac{0.083a^3}{EI}$
$I_{xy} = 0$
$I_{xx} = \frac{0.083h^2}{EI}L$
$I_{yy} = \frac{0.083a^2}{EI}L$
$I_{xy} = \pm\frac{ah}{EI}\left(\frac{L}{2}\right)$

MOMENTS OF INERTIAS AND PRODUCTS OF INERTIAS ABOUT ANY PAIR OF AXES



$I_{xx} = I_{xx} + Ay^2$ $\quad I'_{yy} = I_{yy} + A(-x)^2$ $\quad I'_{xy} = I_{xy} + Ax(-y)$

NOTE: I_{xx}, I_{yy} ARE MOMENTS OF INERTIA THROUGH CENTROID OF SECTION AND ARE ALWAYS POSITIVE

I_{xy} IS THE PRODUCT OF INERTIA THROUGH CENTROID OF SECTION, AND IT MAY BE POSITIVE OR NEGATIVE DEPENDING ON THE SLOPE. IN GENERAL IF $\frac{dy}{dx}$ IS + THEN THE PRODUCT OF INERTIA IS POSITIVE, AND IF $\frac{dy}{dx}$ IS −, THE PRODUCT OF INERTIA IS NEGATIVE

'A' = PLASTIC AREA = $\frac{\text{LENGTH}}{KEI}$ FOR CURVED MEMBERS = $\frac{\text{LENGTH}}{EI}$ FOR STRAIGHT SECTIONS

'x' & 'y' - COORDINATES

SIGN CONVENTION FOR COORDINATES

Tight Anchors

The function of the tight anchor should be to localize forces and moments between two points caused by expansion of the pipe bend. Obviously the closer the anchor points are to each other, the smaller the deflection. The problem then is one of determining a suitable contour of the pipe line, flexible enough to yield readily to expansion, and not overstress any component parts of the line. Such a line however, must be rigid enough to prevent vibrations, if any should be set up.

In order to prevent slipping of the line, and angular rotation at the anchor, the tight anchor should be designed to resist safely, and without excessive deflection, all of the forces impressed upon it. Otherwise its function as a restraining agent is nullified, distortions, displacements and slippage will occur, and the elastic action of the pipe bend is then an indeterminate factor.

Erosion and Corrosion

From the purely elastic action of the pipe bend, erosion and corrosion may have a salutary effect on the lines. The action of these forces tends to diminish the thickness of the wall, and in so doing decreases the moment of inertia of the cross section. This decrease results in gradual reduction of the forces, and perhaps is one of the helpful features in preserving the equipment from severe distortion.

In order to expedite analysis of bends, a table of inertias through centroid of pipe bends is included in Figure 5.

REFERENCE

[1] The above analogy was first formulated by Professor Cross of University of Illinois. The general treatment of the subject, including vertical loading will be found in Bulletin 215, published by University of Illinois in 1930.

NOTE

The author, Mr. Wolosewick is connected with Sargent and Lunday, Engineers, Chicago.

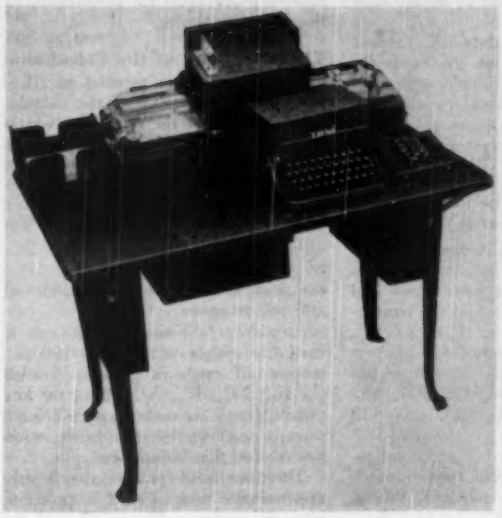


Figure 1. Key Punch. (Used to record alphabetical and numerical data on tabulating cards in form of punched holes.)

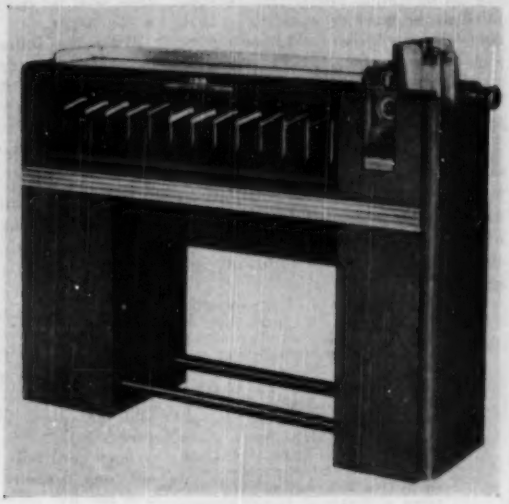


Figure 2. Punch Card Sorting Machine. (Used to sort or group all cards of similar classification.)

Multicomponent Vapor-liquid Equilibrium Calculations Made by Punch-card System

J. W. DONNELL and
KENNETH TURBIN
Michigan State College,
East Lansing

THIS ARTICLE outlines a rapid and accurate calculation method utilizing standard accounting machines. These machines are to be found in the accounting departments of most refining companies. It is thought that engineers utilizing these methods can supply a set of simple instructions to the regular accounting machine operators that will allow the handling of plant flash calculations by telephone. For most problems answers should be obtained in five to ten minutes. This represents a marked saving in time over the usual slide rule trial-and-error procedure.

Donnell is professor of chemical engineering at Michigan State College and Turbin is a graduate student there in chemical engineering.

THE need for rapid and accurate solution of equations for vapor-liquid equilibrium in multicomponent mixtures in the petroleum industry has been evident for years in connection with design and operation of distillation columns, condensers, reboilers, etc., in natural gasoline, general refining and petrochemical plants. The need for these equations is also great in analysis of oil gas separator operations and studies of changes in composition of reservoir fluids with pressure decline in crude oil production. The three main equations involving boiling point, (bubble point), dew point, and mol fraction vaporized upon flash vaporization are:

$$\Sigma K_n X_n = 1, \Sigma \frac{Y_n}{K_n} = 1, \Sigma \frac{Z_n}{1 + (K_n - 1)v} = 1$$

where: X_n = mol fraction of n^{th} component in liquid phase

Y_n = mol fraction of n^{th} component in vapor phase

Z_n = mol fraction of n^{th} component in hydrocarbon mixtures before vaporization

$K_n = \frac{Y_n}{X_n}$ = Equilibrium constant for n^{th} component at the given temperature and pressure

v = Fraction (mols) of original mixture vaporized after equilibrium is attained.

The calculations are relatively simple, merely finding the proper temperature or pressure such that the sum of the products, Kx, equals one for the boiling point determination and the sum of the quotients, y/K, equals one for the dew point determination. In case of the fraction of the original mixture that is vaporized after flash vaporization at a given pressure and temperature the proper fraction v must be selected such that the sum of the fraction $\frac{Z_n}{1 + (K_n - 1)v}$ for each component is equal to unity. It is evident that even though the calculations in themselves are relatively simple the trial and error method of calculation makes many of these problems long and tedious.

This paper outlines a rapid and accurate calculation method utilizing the standard IBM electric accounting machines. These machines are found in the accounting department of most refining companies. It is not intended that the engineer, personally, should go to the accounting department and make these calculations but that a defi-

nite set of simple instructions be supplied to the machine operator so that the engineer would merely have to telephone data to the machine operator and in the course of five to ten minutes have the desired results reported back to him.

The boiling point and dew point calculations will first be described. The method used in these calculations is based on the ease and rapidity with which the IBM electric accounting machine can perform the following operations:

1) The recording of a large quantity of data, on IBM cards, eg., K values for a number of components at various temperatures and pressures.
2) The sorting of any particular card or group of cards from this large amount of data, eg., the removal of K values for a given set of components at a given temperature and pressure—cards are sorted automatically by machine at a rate of 11 per second.
3) The rapid punching and printing of multipliers or dividends on selected data cards together with the resulting quotients or products, eg., the punching and printing of liquid or vapor analysis on the selected K cards and the resulting Ky or $\frac{y}{K}$ values.
4) The rapid summing up and printing of the products or quotients from the cards from item (3), eg., the Kx or y/K values permitting the immediate selection of the proper temperature or pressure that gives the Σ Kx or $\Sigma \frac{y}{x}$ closest to unity.

These four examples are in reality the actual calculations in question, but these will be outlined in detail later in the paper.

After the initial data (K values) have been recorded on the cards the operations outlined above will take approximately 5 minutes for the boiling point determination at a given pressure for five components, (as an example).

Preparation of the Permanent Data Cards

These cards should contain all possible K values for the components in question for various pressures and temperatures. Assume that the temperature range is from 60° F. to 300° F., in five-degree increments, (49 temperatures) and the pressures selected are 14.7, 20, 40, 60, 100, 150, 200, 300, 400, 500, 1000, 2000, 3000 psia. (13 pressures).

Each card will be for one component, one pressure, five temperatures, and the five corresponding K values. If 10 components are under consideration, the number of cards required will be 10 x 49/5 x 13 = 1300.

The different values are punched on the cards in the key punch, (see Figure 1) an instrument having typewriter keyboard. The individual cards do not have to be handled as they are fed automatically to this machine. Some six to eight man hours should be required for this operation. The cards are sorted for the permanent files into stacks of common pressures, and the individual stacks have their cards restacked according to components. This sorting is done at a speed of 11 cards per second. Two man days should be more than adequate for preparation of the permanent files.

The Mechanics of the Calculation

Perhaps the best method of illustrating the mechanics of the calculation is to outline the steps involved in an actual example. Suppose we have a hydrocarbon liquid of the following composition (mole %):

$C_3 = 13.7$
$IC_4 = 20.2$
$NC_4 = 28.6$
$IC_5 = 26.4$
$NC_5 = 11.1$

and wish to know its boiling point at 100 psi. pressure.

Step No. 1—From permanent K card file withdraw from the 100 psi. section all cards in columns headed C_3, IC_4, NC_4, IC_5, NC_5. With the key punch, punch the mole fraction of each component on the ten cards, withdrawn, for that component.

The time listed for each step is only approximate and is only intended to give the reader a general idea of the time consumed in these calculations. (Time for step No. 1, 3 minutes.)

Step No. 2—Sort the 50 cards according to temperatures, on sorter. See Figure 2. (Time for step No. 2, ½ minute.)

Step No. 3—Place cards from step No. 2 in calculating punch (see Figure 3) where the product of the analysis and the K are punched on the cards. (Time for step No. 3, 1 minute.)

Step No. 4—Place cards for step No. 3 in accounting machine (see Figure 4) which sums up the products and prints the results beside the respective temperature. Then pick out

Figure 3. Calculating Punch. (Used to add, substract, multify, or divide simultaneously or successfully and punch the results on the card as it passes through the machine.)

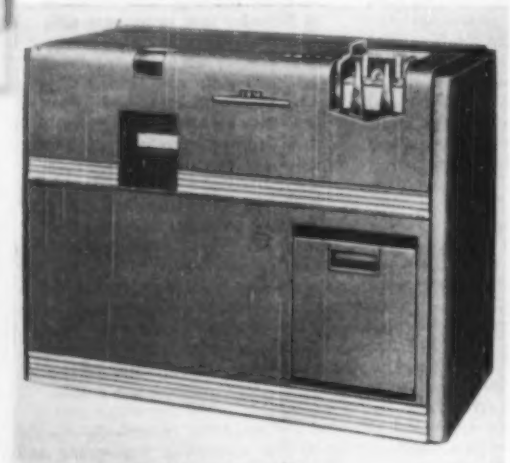
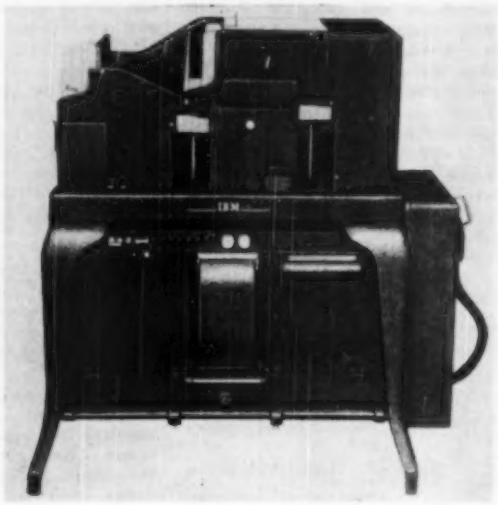


Figure 5. Reproducing Punch. (Used to prepare duplicate of punched cards at high speed.)



the temperature whose product is nearest unity, and that temperature is the boiling point. (Time for step No. 4, ½ minute.) Total time, 5 minutes.

If the value of K at five temperatures is put on each card, there will be sufficient space to perform only two calculations. The cards that have been used twice will be replaced in the files by duplicates which are made automatically from the originals on the reproducing punch. Figure 5.

If it is desired to use one-degree increments of temperature instead of five degree, five times as many cards will be required for the complete file. Under these conditions it would be advisable to make a preliminary calculation using 50-degree increments, and then make the final calculation using the 50-degree increment that was found to be closest to unity.

A calculation of the dew point of a hydrocarbon vapor is carried out in exactly the same fashion as the boiling point calculation except that the calculating punch is set to divide instead of multiply.

The determination of the boiling point pressure at a given temperature requires that the cards be resorted into stacks of common temperatures, and the individual stacks resorted, as before, by components. The calculation itself would be the same as previously outlined. If both types of calculations are to be performed, i.e., determination of boiling point temperatures and pressures, it would be convenient to have a duplicate set of cards run off on the reproducing punch, and to have one set filed by constant pressures and the other by constant temperatures.

The equation for the calculation of the fraction vaporized upon flash vaporization utilizes essentially the same fundamental principles of the IBM machines as employed in the boiling point and dew point calculations except in somewhat different fashion. The mechanics of the calculation will be illustrated by outlining the steps involved in the determination of the fraction of the original liquid (using the same hydrocarbon liquid used for the boiling point and dew point calculations), that will be vaporized when the mixture is subjected to a flash equilibrium vaporization at 100 psi. and 160° F. temperature.

Step No. 1—From permanent K card file withdraw from the 100 psi. section all cards in columns headed C_3, IC_4, NC_4, IC_5, and NC_5. Machine sort the 50 cards for the five cards, one for each component, having the temperature 160° F. (Time for step No. 1, ⅓ minute.)

Step No. 2—With the key punch, punch the mol fraction of each component (Zn) together with the No. 1 on its respective card. (Time for step No. 2, 1 minute.)

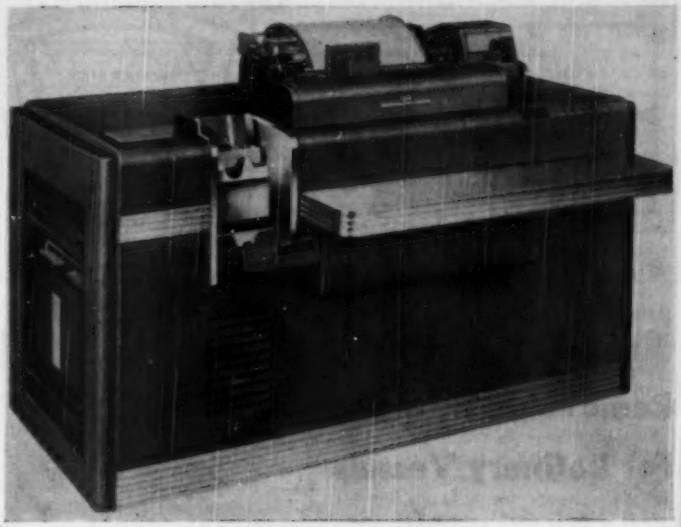


Figure 4. Punched Card Tabulating Machine. (Used to read the punched cards and record any desired combination of totals at high speed)

Step No. 3—Place the five cards from step No. 2 in the reproducing punch and prepare 29 duplicate cards for each of the five original cards. (Time for step No. 3, 2 minutes.)

Step No. 4—From step No. 3 take nine cards from each component stack and with the key punch, punch one of the following values of v on each card .1, .2, .3, .4, .5, .6, .7, .8, .9. (Time for step No. 4, 2 minutes.)

Step No. 5—Place cards from step No. 4 in a properly wired calculating punch and perform the calculation of fraction $\frac{Zn}{1+(K_n-1)v}$ for the 45 cards. (Time for step No. 5, 4 minutes.)

Step No. 6—Place cards from step No. 5 in their five groups of nine each in the accounting machine. This machine sums up the fractions and prints the results beside the respective value of v. (Time for step No. 6, 1 minute.)

Step No. 7—Select from step No. 6 the 10 per cent increment whose sum of the fraction $\frac{Zn}{1+(K_n-1)v}$ is nearest unity and repeat steps No. 4, 5, and 6 except using ½ per cent (.005 fraction) increments for v within the 10 per cent v increment selected at the start of step No. 7. The answer will be the value of v whose $\frac{Zn}{1+(k_n-1)v}$ is nearest unity for tabulator repeating step No. 6.

With some of the later type calculating punches it is possible to combine step Nos. 5, 6, and 7 (flash vaporization calculation) into one operation which automatically selects a new value of v if the summation does not equal unity. This type of machine would, of course, materially reduce the calculation time. The same machine could be applied to the boiling point and dew point calculations with a considerable saving in calculation time.

It is realized that K is not only a function of pressure temperature and component but in some cases may be materially affected by the vapor and liquid composition of the mixture. In the latter case a little ingenuity and the use of more K cards will enable these calculations to be carried out with little additional time.

In conclusion we should like to point out that not only as much as 75 per cent of the time normally consumed in the foregoing calculations can be saved by the use of IBM machines but the remaining 25 per cent of the work can be carried out by IBM machine operators without the danger of errors.

Work is also being carried out for the development of an accounting procedure by which the machines can be used to calculate the number of trays in a fractionating tower.

F. B. Martin, supervisor of IBM machines at Michigan State College has been very helpful in the preparation of this article, having set the machines to carry out the calculations and acted as adviser throughout.

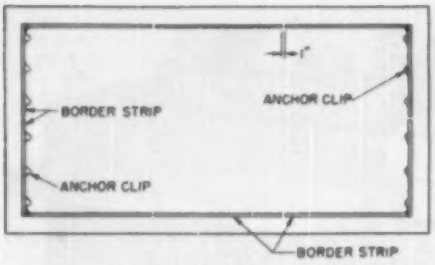


Figure 1-A. Typical Vessel Shell Plate.

Figure 1-B. Typical Vessel Shell Plate.

Removable Insulation Provided For Refinery Vessels

MARSHALL F. ALLEN

Manager, The Magnesia Insulation Manufacturers' Association

A SYSTEM of insulation installation that is especially practical for use with process plant pressure vessels subjected to severe service conditions is outlined here. The system allows ready access to welded joints and other critical points for inspection purposes.

VESSELS subject to high temperatures and stresses and constructed of welded stainless steel-clad carbon steel plates present particular insulation difficulties. All vessel welds, both horizontal and vertical, must be available for periodic inspection to detect possible weld corrosion or cracking. Removable insulation must therefore be provided over weld seams if exorbitant reinsulation costs are to be avoided. Secondly, because of operating temperatures involved, expansion joints must be provided in the insulation to allow for both lateral and longitudinal expansion of the vessel.

Over a period of years, an insulation procedure has been developed which has successfully solved both of these problems. The procedure consists essentially of three parts: 1) application of permanent insulation on the vessel plates; 2) application of removable insulation over weld inspection lanes; and 3) installation of sheet metal jacketing. The insulating material used is 85 per cent magnesia, applied alone, or in combination with diatomaceous silica.

Insulation of Vessel Plates

Each plate of a vessel is individually insulated. Before the insulation is applied, border strips made of ¼-inch thick metal plate, about 2 feet long and width depending upon the thickness of insulation to be used, are tack-welded to the vessel plate about 3 inches from the vertical and horizontal welds. The border strips are applied so that they are spaced about 1 inch apart except at the corners where they are butted together. The arrangements for a rectangular and triangular plate are shown in Figure 1.

Welded flat on to each border strip are short loops of wire, spaced about 1½ inch from the outer edge and about 1 foot apart. (These loops are used to fasten the removable insulation panels over the inspection lanes, as described later.) On the vertical strips, near each wire loop is an anchor clip welded to the strip at an angle of 45 degrees. Assembly detail is shown in Figure 2.

A layer of insulation blocks is applied with the long dimension in the vertical position and vertical joints staggered. The blocks are butted against the horizontal border strips, but a 2-inch space is left between the insulation and the vertical strips on either side. (These spaces will contain the expansion joints, to be described later.) The blocks are fastened in place with wiring tied to the anchor clips on the vertical strips.

Anchor plates with flat head, threaded stove bolts tack-welded at 1-foot intervals along the center of the plates are then applied (see Figure 3). The plates are of No. 20 gauge sheet metal, 6 inches wide and length

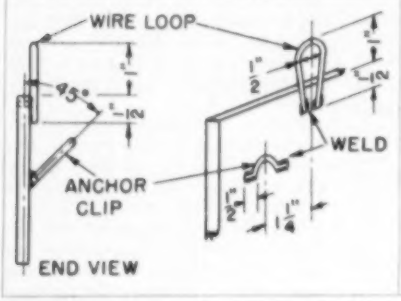


Figure 2-A. Figure 2-B. Detail of Border Strip.

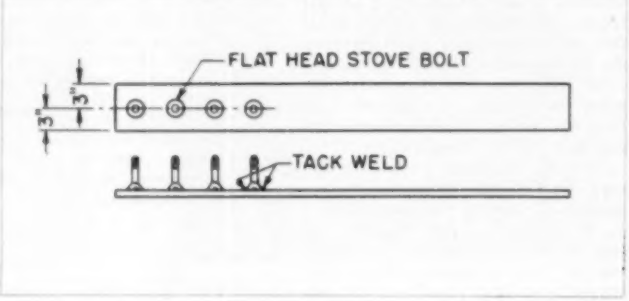


Figure 3. Anchor Plate.

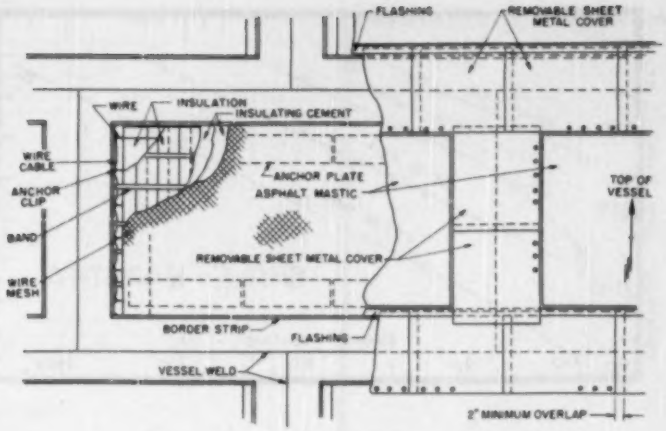


Figure 4. Typical Plan View of Vessel Insulation.

varying with the dimensions of the vessel involved. With the long dimension in the horizontal position, the plates are slipped in place between the insulation tie wires and the insulating blocks and arranged so that one row is just below the top horizontal border strips and one just above the bottom border strips.

The second layer of insulation blocks is then applied by forcing them on the stove bolts until they are firmly against the anchor plates and the bolts protrude through the outer surface of the insulation. The block dimensions and the placement of the bolts are such that the joints in the outer layer of insulation are staggered with the joints in the inner layer. The outer layer of insulation is further secured in place by means of horizontal bands anchored to wire cables looped through the anchor clips on the vertical border strips.

Two ¼-inch layers of insulating cement are then applied over the entire surface of the insulation. A layer of hexagonal galvanized wire mesh is stretched over the cement and wired to the same cables used for anchoring the horizontal bands mentioned above. The horizontal edges of the wire mesh are bent over the insulation and pressed flat. The insulation is finished with a layer of weather-resistant asphaltic mastic, ⅛-inch thick when dry, and troweled smooth.

Removable Insulation on Inspection Lanes

At this stage of the procedure, every vessel plate has been insulated in the manner described above and at both sides of the vessel welds is a 3-inch uninsulated area, providing inspection lanes 6 inches wide. Removable insulation panels for these inspection lanes are constructed as follows:

A double layer of insulation blocks is arranged in the form of a rectangle, 6 inches wide and 3 feet long, and held together by asbestos bonding cement. Galvanized hardware cloth is placed over the blocks and bent over both long sides of the panel so that it extends to the middle of the under block layer. The edges of the hardware cloth are bent and hammered into the sides of the under layer of blocks so that the two layers will be held together as a unit. The cloth is held in place with staples hammered into the insulation. A layer of hard finish cement is applied over the hardware cloth as well as over the exposed sides of the insulation and the panel is ready to be placed in position. The panels are placed over the welds between the border strips and secured in place with wires anchored to the wire loops near the edge of the border strips.

Application of Metal Jacketing

The 2-inch spaces left between the permanently installed insulation and the border strips are packed tightly with asbestos fibrous insulation. This allows for expansion of the vessel.

Flashing strips of No. 20 gauge sheet metal, 6 inches wide, are placed over the fibrous insulation to serve as a finish. At one side of the vertical inspection lanes, flashing with a crimp forming a slot is installed over the expansion joints; at the other side, the flashing strips are flat. Flat flashing strips are also used over the horizontal edges of the permanently installed insulation. Drilled holes in the flashing are spaced so that the stove bolts welded to the anchor plates will fit through them. Nuts are screwed on the stove bolts and tightened against the surface of the flashing.

The removable insulation panels for the inspection lanes are finished with removable covers of No. 20 gauge sheet metal. On the vertical lanes, one edge of the cover slides into the slot in the flashing at one side of the lane and is bolted to the flashing on the other side. On the horizontal lanes, one edge of the cover slides under one of the flashings and is bolted to the other.

Figure 4 shows a typical plan view and Figure 5 shows a cross-section of the installation.

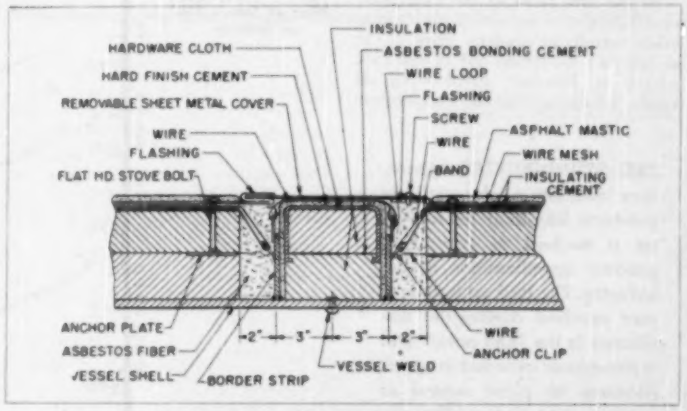


Figure 5. Cross Section of Vessel Insulation.

* * *

Endpoint Determinations Sharply Influenced by Test Variations

GEORGE E. MAPSTONE
Chief Chemist, National Oil Pty., Ltd.,
Glen Davis 6W, N.S.W., Australia

THE STANDARDIZED laboratory distillation of petroleum products has long been used as a method of control of product specifications in the industry. The highest temperature reached during the distillation is the "end point" and is sometimes included in specifications for plant control or marketing purposes. The author here records some of the factors that influence the determination of the end point of the laboratory distillation.

IN THE standard distillation methods ASTM D86-46, ASTM D216-40, and I.P. 123/49A for the distillation of gasoline, "direct heat shall be applied (to the flask) only through the 1¼ inch opening in the first (smaller) asbestos board" in the stand.

During part of the war years, the only available asbestos board tended to crack in use and this caused frequent flask failures with their consequent fires. In order to reduce the hazard, the flask was raised just above the hole. This had no effect on the results of the distillation except the end point which was frequently high. These high results are easily attributed to the superheating of the oil vapors in the flask by the flame gases passing up past the neck of the flask.

In order to obtain a quantitative indication of this superheating effect, several distillation tests were carried out on one sample of gasoline by a number of testers, and the effect of the position of the flask noticed. The results presented in Table 1 show that, not only were the results erroneously high due to raising the flask, but also the reproducibility was affected.

The work was later repeated with a sample of Dubbs recycle light oil of 560° F. E. P. (Method ASTM D158-41, I.P. 123/49C) using a 250-ml. flask seated on a board with a 2⅜ inch diameter hole. Because of the much higher end point, the flask position was not as critical as with the gasoline, but removal of the board altogether gave results which were from 10° to 25°F. high.

Effect of Flask and Sample Size

At the end point of the laboratory distillation of a sample of gasoline or other petroleum product, there is (or should be) no liquid left in the flask which is, however, filled with oil vapor. Assuming that the temperature of the vapor in the flask is that recorded as the end point of the sample, the vapor is equivalent to:

$$\frac{V_f}{22400} \times \frac{492}{460 + t} \times \frac{M}{D}$$

ml. of the liquid sample

where

V_f = capacity of flask in ml.
t = observed end point of the distillation in °F = T°R
M = molecular weight of the vapor.
D = density of the liquefied vapor.

The proportion of oil left as vapor in the flask at the end point of the

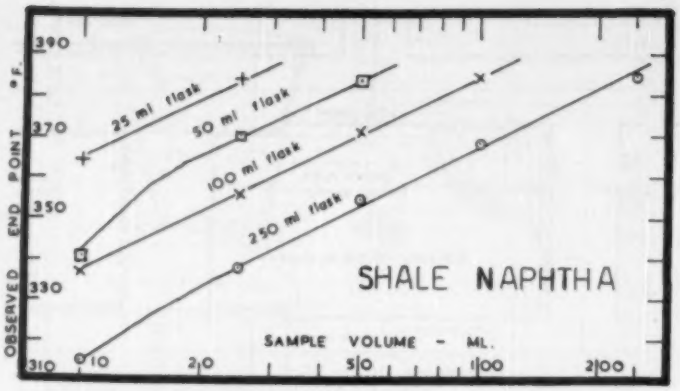


Figure 1. (Top of page) Effect of Sample Size on Endpoint.

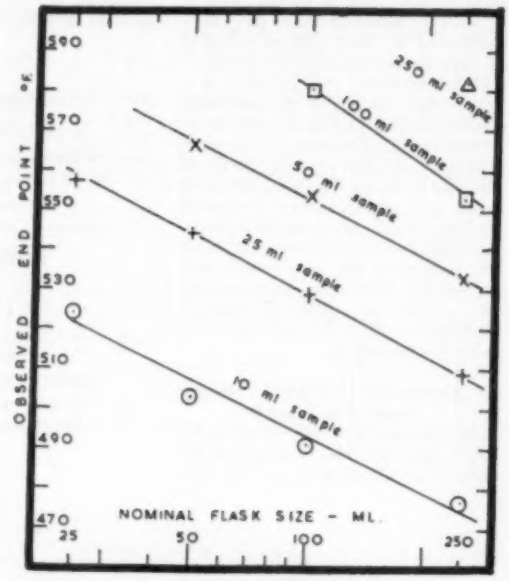


Figure 2. Effect of Flask Size on Endpoint (Dubbs Recycle Light Oil).

TABLE 2

Nominal Flask Size V_f ml.	Sample Size V_s ml.	V_s/V_f	Gasoline	ENDPOINT—°F. Shale Naphtha	ENDPOINT—°F. Dubbs Light Oil
250	250	1.0	390 (7)	385 (8)	582 (7)
250	100	0.4	371 (8)	360 (5)	553 (9)
250	50	0.2	356 (8)	354 (5)	533 (9)
250	25	0.1	342 (6)	338 (8)	509 (6)
250	10	0.05	315 (6)	315 (5)	477 (4)
100	100	1.0	394 (4)	385 (9)	580 (4)
100	50	0.5	379 (7)	371 (7)	553 (5)
100	25	0.25	362 (6)	356 (10)	529 (8)
100	10	0.1	344 (6)	337 (5)	491 (9)
50	50	1.0	392 (10)	384 (6)	586 (5)
50	25	0.5	365 (10)	370 (6)	544 (4)
50	10	0.2	346 (10)	341 (6)	503 (4)
25	25	1.0	380 (10)	384 (6)	557 (3)
25	10	0.4	362 (10)	364 (8)	534 (7)

The above results are the average of those obtained by six different testers carrying out the distillations over a period of approximately a month. The figures in parentheses after the end points refer to the number of results averaged.

distillation is therefore

$$\frac{V_f}{V_s} \times \frac{1}{T} \times \frac{492}{22400} \times \frac{M}{D} = V_r \qquad (1)$$

Where

V_s = volume of the original sample,
V_r = proportion of the sample undistilled.

If the ratio V_s/V_f is varied, the end point of the distillation will be automatically affected because of the different proportion of the sample distilled. Over the small range of composition of the sample thus affected, the molecular weight and liquid density could be taken as approximately constant. The proportion of the oil left in the flask as vapor at the end point of the distillation can therefore be written

$$V_r = \frac{V_f}{V_s} \cdot \frac{K}{T} \qquad (2)$$

The distillation range of the sample may be expressed as

$$V_r = f(T) \qquad (3)$$

Whence

$$T.f(T) = K V_f/V_s \qquad (4)$$

The end points of samples of gasoline, shale naphtha and Dubbs recycle light oil were determined over a range of conditions of flask and sample size. When using the 250-ml. flask, the equipment was set up as for ASTM method D158-41 and the specified distillation rate followed as nearly as possible. When using the 100, 50, and 25-ml. flasks, the 1¼ inch asbestos board and the specified distillation rate of ASTM method D86-46 were used though, with the 25-ml. flask, the distillation rate was frequently slower to prevent the sample boiling over.

The results of these tests presented in Table 2 confirmed the decrease in the end point by reducing the sample size or increasing the flask size. The effect of sample size on the end point is shown graphically for shale naphtha in Figure 1 and the effect of the flask size on the end point is shown for Dubbs recycle light oil in Figure 2.

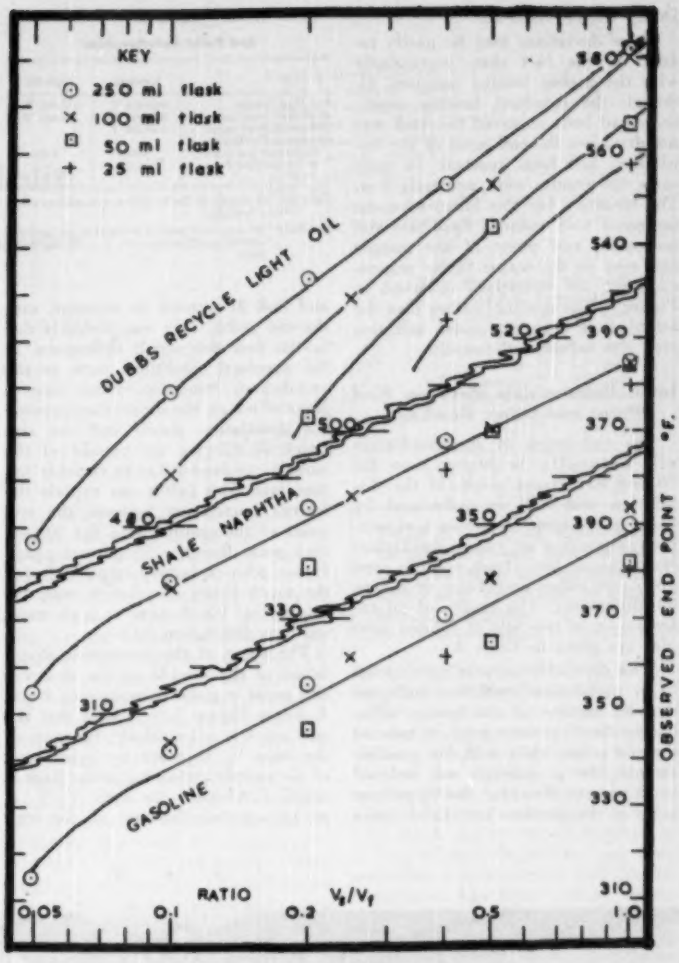


Figure 3

In Figure 3, the observed end points have been plotted against the ratio of the sample size to the nominal flask size for each of the samples listed in Table 2. Since, if V_s/V_f is constant, V_r and therefore also, the end point of the distillation, should be constant. This is approximately so for the sample of the shale naphtha, but the results with gasoline in 25 and 50-ml. flasks varied while there appears to be no simple correlation with the

TABLE 1
Effect of Flask Position on End Point

FLASK POSITION	TESTER A	B	C	D	E	Average
1. On Plate	387	388	385	383	383	386 °F.
	388	...	...	384	386	
	388	...	...	386	388	
2. ¼" Above Plate	400	...	396	402	384	394 °F.
	...	...	...	386	410	
	...	...	...	386	397	
3. ½" Above Plate	...	...	...	387	...	401 °F.
	...	...	...	408	394	
	...	...	...	386	412	
	...	...	...	404	390	
4. ¾" Above Plate	...	...	...	396	...	407 °F.
	406	...	...	386	407	
	407	...	...	...	410	

Dubbs recycle light oil.

These deviations may be partly related to the fact that, particularly with the higher boiling samples, although the standard heating conditions had been observed the flask was not dry when the end point of the distillation had been reached. In such cases the results were naturally low. The tendency for this effect to occur increased with reduced flask size and increasing end point of the sample and may be the major factor responsible for the deviations observed in Figure 3. The nominal rather than the actual flask size was used and this may also influence the results.

Inter Relationship Between End Point and Other Readings

The end point of the distillation will naturally be higher than the 90 and 95 percent points of the distillation and will be influenced by many of the same factors such as sample composition etc., while distillation range, vapor loss (from volatile samples) can either accentuate or reduce the differences. The results of an examination of two sets of related samples are given in Table 3.

With the Dubbs recycle light oil the high correlation coefficient indicates that 88 percent of the factors influencing the 95 percent point, influenced the end point, while with the gasoline sample, the proportion was reduced to 12 percent. However, the 90 percent point of the gasoline correlated better and had 21 percent in common with the end point. This was probably due to the fact that small differences in the standard conditions such as the condenser temperature can have a large effect on the differences between the distillation points and the end point by varying the volume of the sample condensed due to variable butane loss. This factor can explain the better correlation between the end point of the gasoline and the 90 percent point than the 95 percent point. It may also be largely responsible for the much better correlation with the heavier oil which gave a much more uniform distillation recovery.

TABLE 3

End Point Relationships

	Gasoline	Light Oil
End Point (range)	360-390 °F.	482-510 °F.
95 Percent Point (range)	330-382 °F.	470-500 °F.
90 Percent Point (range)	305-355 °F.	.....
Correlation Coefficient:		
95 Percent End Point	0.345	0.939
90 Percent End Point	0.456	.....

Light Oil: 45 samples of Dubbs light recycle oil drawn over a fortnight.

Gasoline: 104 samples of gasoline prepared to the same distillation specifications over a period of eleven years.

The effect of the incomplete distillation of the sample on the observed end point is given by equations 3 and 4. From Figure 3 it is seen that the end point is a logrithmic function of the ratio V_s/V_f when the proportion of the sample remaining in the flask is small. Conversely the ratio V_s/V_f is an exponential function of the temperature which is in approximate agreement with the observed upward "tail" of the usual laboratory distillations.

Rapid Testing

It has sometimes been convenient to use the end point of various distillates for plant control purposes. The repeatability of the test is 5°F. but this was well within the control limits employed, so did not affect the value of the test for control purposes. Because of the time required to carry out the test under the standard conditions, several attempts were made to speed up the method without impairing the results.

It was found that, as long as the last 10 percent of the sample were distilled at the standard rate, the first 90 percent could be distilled as rapidly as the equipment would permit without significantly affecting the end point.

Various methods in standard and nonstandard equipment were examined, but none was suitable, though in some cases, results were obtainable in 5-6 minutes as against 25-30 minutes by the standard method. The effects of vapor superheating and of the sample/flask ratio interfered and when they were approximately balanced, the reproducibility of the method was unsuitable, the best methods giving results within a range of 20°F.

ACKNOWLEDGMENTS

The author wishes to acknowledge with thanks the permission granted by the management of National Oil Pty., Ltd., for the publication of this article.

* * *

ANOTHER 75 YEARS—Continental Oil Company "broke ground for another 75 years" September 12, at ceremonies launching construction of a new $2,250,000 research center in Ponca City, Okla., and inaugurating a series of employe celebrations over the nation in observance of the company's seventy-fifth anniversary. L. L. Davis, manager of Continental's development and research department, is shown at left with spade as he turned the ground for the projected laboratory building. At the groundbreaking program President L. F. McCollum, extreme right, standing, announced a company college scholarship program for sons and daughters of Continental employes. Others in the picture, standing, are, left to right: W. C. MacMillan, executive vice president; Harold G. Osborn, vice president and general manager of Ponca City operations, and master of ceremonies for the program; Dr. James R. Killian, Jr., president of Massachusetts Institute of Technology, Cambridge, principal speaker; and McCollum.

Distillation Column Balance— Overhead-Bottoms Split vs. the Feed Composition

W. D. HARBERT
Arthur G. McKee & Company,
Cleveland, Ohio

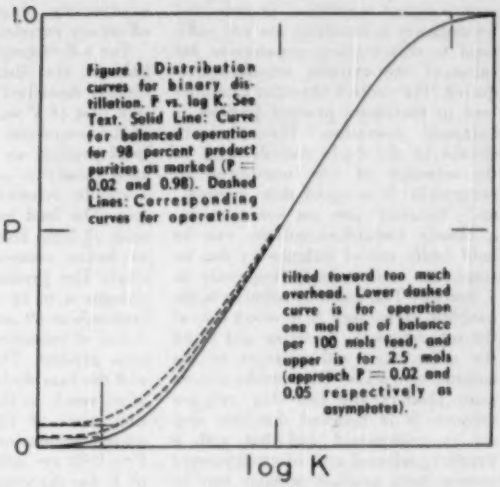


Figure 1. Distribution curves for binary distillation. P vs. log K. See Text. Solid Line: Curve for balanced operation for 98 percent product purities as marked (P = 0.02 and 0.98). Dashed Lines: Corresponding curves for operations tilted toward too much overhead. Lower dashed curve is for operation one mol out of balance per 100 mols feed, and upper is for 2.5 mols (approach P = 0.02 and 0.05 respectively as asymptotes).

Abstract

From an analogy with a weighing scale, a "balanced" distillation operation is defined as one in which the division of the feed mixture between the overhead and bottoms products conforms to the percentages of the light and heavy components in the feed so that maximum product purities result. If the operation is "out of balance" or "tilted" toward either too much overhead or too much bottoms, then one of the components is necessarily forced into the wrong product stream and a poorer separation is obtained. In general, the degradation of an amount of heat across a given number of plates merely makes a certain separation available, and only if the column is in exact balance can this separation be fully realized. Unless the column is deliberately instrumented and controlled for balance the separations obtained are, within certain limits, accidental.

It is believed that this difficulty of the column balance is the primary reason for the present division of the distillation field into two separated sections: the elaborate and seemingly complete and consistent theory; the poorer and unpredictable actual operations of the columns. The common connection between theoretical and actual performance has been the "plate efficiency," and low and irregular efficiencies have been calculated for columns of the most careful design. It is believed that plate efficiencies have been confused with balance as a source of poor separations, and that actual low efficiencies are of secondary importance in explaining the theoretical—actual differences. With the added requirement of balanced operation, the full separating power prophesied by theory may very well be realized in commercial distillation.

THIS STUDY of distillation factors may well lead to improvements in the instrumentation and operation of commercial columns.

AS A FIRST illustration consider a distillation column the feed to which contains 75 mols of light component and 25 mols of heavy component per 100 mols total. But, if this column were operated to give only 50 mols of overhead product together with 50 mols of bottoms product, the latter must necessarily contain 25 mols of the light component and so can only be 50 percent pure. It is obvious that no amount of increased heat through the column or additional numbers of plates can improve this purity past 50 percent as long as the 50-50 division between overhead and bottoms is maintained. But if the product split were shifted to 75 mols overhead—25 mols bottoms to conform to the feed composition the column would begin to give the full product purity of which it was capable.

In this column too much bottoms was being produced, and a similar example could be given for a column producing too much overhead. From an analogy with a knife edge weighing scale and its ability to tilt in either direction, this property of a distillation column of producing too much overhead or too much bottoms is termed the column "balance". When the division between overhead and bottoms conforms to the percentage of the light and heavy components in the feed, the operation is "balanced." This condition results in the maximum separations being obtained for the heat duties and numbers of plates used. Any column for which the division of the feed is other than this optimum is "tilted" or "out of balance," and the separation can be improved by adjusting the overhead-bottoms ratio.

The phenomena resulting from a column being out of balance are, of course, widely recognized, and are part of the everyday knowledge of operating men. A common term applied is "driving it out the bottom" or "driving it out the top." However, it is believed that the problem has been somewhat misunderstood, and that its importance has been greatly underestimated. It has been generally ignored by distillation theorists, and no solution other than the direct and continual loss of product purity seems to have been suggested. It is to be emphasized that balance is a basic and expensive distillation difficulty. It is not a minor and occasional problem that may require a change in the control settings. Rather, it is a continual and costly factor in any distillation in which reasonably sharp separations are desired. For very sharp separations it becomes of predominate importance. The loss of product value resulting from a lack of balance can easily equal or exceed the total cost of the distillation operation.

In the present paper "balance" is introduced as a mathematical entity, and an elementary discussion of its properties and graphical representation is given. Also three specific points are made as follows:

First: For most processes the objective of the control system is to hold constant conditions. But in distillation

such constant conditions as measured by ordinary instruments are not sufficient to insure sharp separations because of the extreme sensitivity required. The control objective that does lead to maximum product purities is balanced operation. Then balance should be the basic consideration in the selection of the instrument arrangement. It is noted that "control" and "balance" are not synonymous; a closely controlled column can be held badly out of balance by the instruments, and, indeed, frequently is.

Second: The common solution to the problem of balance is to select one of the separations to be sharp and to let the other vary with changes in the column operation. This results in one pure product and one slop cut per column. It is believed that this slop cut is unnecessary and that with a properly selected and adjusted control system both product streams can be obtained in continuous high purity. The instrument system to accomplish this is necessarily more complicated than the minimum for control which is commonly considered to be most desirable.

Third: A lack of balance is believed to be the principal reason for discrepancies between distillation theory and the actual operations of the columns. And yet plate efficiencies are frequently accepted as being the only cause of the theoretical-actual differences.[1] Only in the discussion of column control by instrument engineers[3, 4] is the problem of balance described. It would seem probable that for a majority of the columns for which low plate efficiencies have been calculated the poor separations reported actually resulted from a lack of balance. The failure to include balance as a distillation variable is believed to be the major reason for the shotgun scattering obtained in most plate efficiency correlations.

For a first graphical look at column balance, the distribution curves previously described[2] are useful. Figure 1 is a plot of P vs. log K (the fraction of the component that goes to the overhead product vs. the log of an averaged volatility—see nomenclature) for a simple, symmetrical binary distillation. The feed mixture consists of 50 mols of light component and 50 mols of heavy component for 100 mols total. The product impurity in both streams is to be 2 percent which corresponds to 49 mols of component and 1 mol of impurity to make 50 mols of each product. The numbers of plates and the heat duties used for this operation result in the solid line distribution curve of Figure 1, and the required separations of $P = 0.02$ and $P = 0.98$ are marked off at the values of K for the components.

But, the happy condition of obtaining the 98 percent product purities for these conditions requires that the bottoms-overhead split be exactly 50-50, i.e., that the column be balanced. Suppose that the split actually obtained in 51 mols overhead—49 mols bottoms so that the column is out of balance by one mol. The one mol of light impurity in the bottoms product would change very little. Then, by material balance the heavy impurity in the overhead must be about 2.0 mols instead of 1.0, and the overhead impurity becomes 2/51 or about 4 percent as compared with the desired 2 percent. It is seen that with a 50-50 feed composition and a 51-49 overhead-bottoms split at least 1 mol (2 percent) of the heavy component must be in the overhead product no matter what the amount of heat or numbers of plates. Then the lower end of the distribution curve must approach $P = 0.02$ as an asymptote instead of $P = 0$. Similarly, if the split is 52.5 mols overhead-47.5 mols bottoms, then at least 2.5 mols or 5 percent of the heavy component must go into the overhead so that the lower asymptote becomes $P = 0.05$. The distribution curves for these two tilted operations are shown as the dashed lines of Figure 1. The loss of separation efficiency for these operations in which the P vs. K curves do not approach $P = 0$ is obvious.

In order to show more fully the effects of column balance, a distribution curve of the form of a direct plot of balance vs. product impurities has been selected. Figure 2 is such a plot of B vs. G where G_C (solid line) and G_R (dashed line) represent the mols of impurities in the condenser and reboiler product streams respectively per 100 mols of feed. The balance factor B represents the number of mols by which the column is out of balance and is also based on 100 mols of feed ($B = V_C^\circ - V_C$, see nomenclature).

As the simplest case, consider the form of the plot of B vs. G for an infinite plate operation in which a complete separation is obtained for a 50-50 binary mixture (lower lines of Figure 2). At the balanced operation of $B = 0$, the overhead-bottoms split is 50-50 and both G_C and G_R are zero. But, suppose the split becomes 49 mols overhead-51mols bottoms ($B = +1.0$). G_C is still zero because the overhead product remains pure, but G_R necessarily becomes 1.0 as there must be one mol of light component in the bottoms. By inspection, it is seen that from the material balance, the relations $G_R = +B$ and $B_C = 0$ must hold for any positive value of B. Then, if G and B are plotted to the same scale, G_R vs. $+B$

Figure 2. Balance plot of G_C (solid line) and G_R (dashed line) vs. B. All in mols per 100 mols feed (see nomenclature). Lower set of lines is for a theoretically complete separation for which $G_C = G_R = 0$ at the balanced operation of $B = 0$ (requires infinite plates). Upper set of lines is for an incomplete separation for which $G_C = G_R = 1.0$ at $B = 0$.

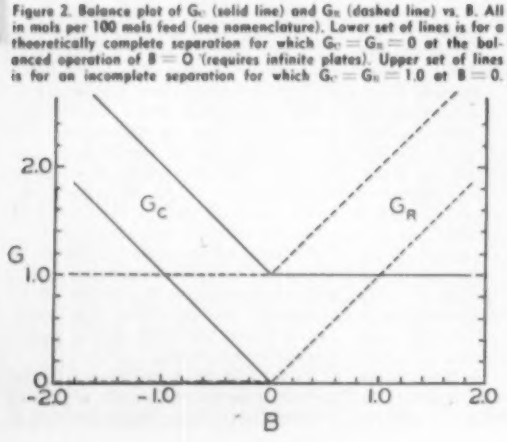
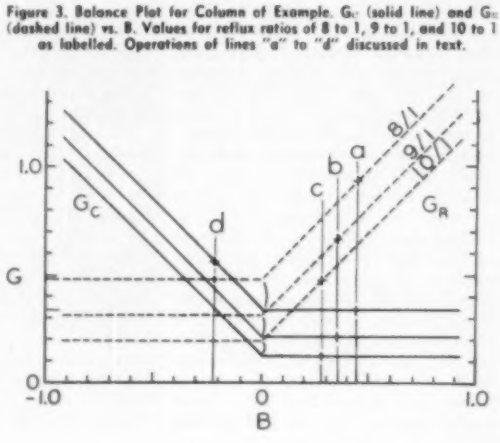


Figure 3. Balance Plot for Column of Example. G_C (solid line) and G_R (dashed line) vs. B. Values for reflux ratios of 8 to 1, 9 to 1, and 10 to 1 as labelled. Operations of lines "a" to "d" discussed in text.



is a line of 45° slope through the point $B = 0$, $G_R = 0$ and G_C vs. $+B$ is the horizontal line $G_C = 0$.

Now, suppose that the split becomes 51 mols overhead-49 mols bottoms ($B = -1.0$). The bottoms product remains pure and $G_R = 0$, but there is necessarily one mol of heavy component in the overhead so that $G_C = 1.0$. It is seen that, by material balance, when B is negative $G_C = -B$ and $G_R = 0$. Then for equal scales the plot of G_C vs. $-B$ is a 45° line through the point, $B = 0$, $G = 0$, and the plot of G_R vs. $-B$ is the horizontal line $G_R = 0$. The resulting complete plot of B vs. G for the case of infinite plates is given by the lower set of lines of Figure 2 (through the point $B = 0$, $G = 0$).

Next consider the form of the B vs. G plot for a finite plate distillation in which an incomplete separation is obtained (upper lines of Figure 2). In the example distillation of Figure 1, a 50-50 binary mixture is separated into 98 percent pure products so that at the balanced operation of $B = 0$ both G_C and G_R equal $50 \times 0.2 = 1.0$ mols. If the split becomes 49 mols overhead —51 mols bottoms ($B = +1.0$), the heavy impurities in the overhead will remain almost the same at $G_C = 1.0$ (but the light impurities in the bottoms are necessarily increased by one mol to $G_R = 2.0$). From a number of points obtained similarly, it is seen that the shape of the B vs. G plot for this case is exactly the same as for the infinite plate case except that the lines are displaced upwards by the values of G_C and G_R at $B = 0$. On Figure 2, the interrelations of the 45° and horizontal lines are identical for the complete separation (lower set of lines) and the incomplete separation (upper set of lines).

Then for the construction of a balance plot, it is necessary to know G_C and G_R at the balanced operation of $B = 0$. The 45° and horizontal lines of B vs. G are then drawn through these points as in Figure 2. With the aid of such a plot, the product compositions can be used to determine the number of mols a column is out of balance. Or the products that would result from any change in balance can be estimated. The effect on the balance of changing the control settings can be used to predict the resulting product purities. The numerous factors which affect the column balance together with the resulting product purities can be reduced to numerical values of *B*.

A convenient way of finding G_C and G_R at $B = 0$ for an operating column is to determine product purities on both sides of the balanced operation (both positive and negative values of *B*). The overhead purity when there is too much bottoms and the bottoms purity when there is too much overhead are the product purities that should be obtained at the balanced operation of $B = 0$. It will be noted that for the complete separation case (lower values of Figure 2) the B vs. G lines are, by material balance, exactly 45° and horizontal. But for actual, incomplete separations this is not precisely so. Other conditions remaining constant, if a heavy component is forced into the overhead product there will be a little less of the light component in the bottoms product. Then the slope of the horizontal lines will be slightly downward from the value of $B = 0$, and the slope of the 45° lines will be correspondingly greater than 45°. However, for values of *B* of less than 1.0 these differences are not important and horizontal and 45° lines are quite satisfactory. This is particularly so as the principal use of the plot is qualitative rather than quantitative.

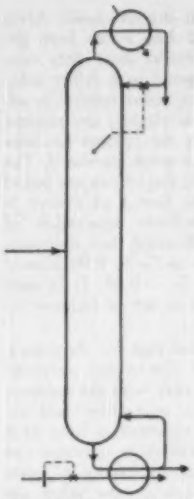


Figure 4. Basic Two-Control System for Column. See text.

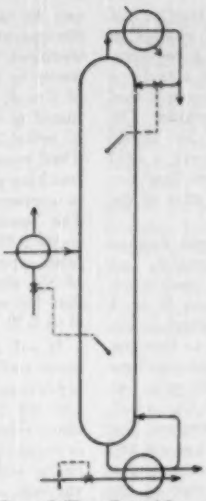


Figure 5. Three-Control System for Maintaining Column Balance. See text.

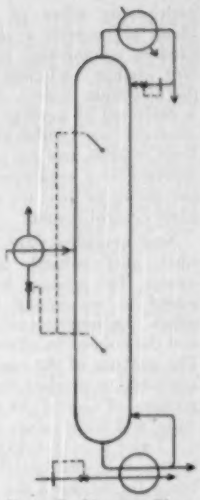
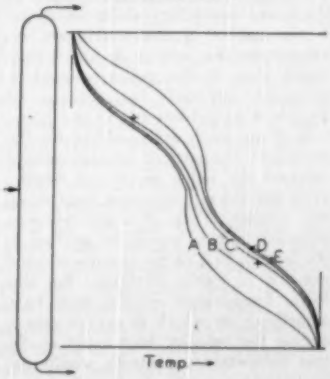


Figure 7. Alternate Three-Control System for Maintaining Column Balance. See text.

Figure 6. Plate Temperature Profiles for a Binary Distillation Showing Five Conditions of Balance from Too Much Overhead to Too Much Bottoms (left to right). Curve C represents the balanced operation.



To show the use of plots of B vs. G a typical simplified binary distillation operation will be analyzed for balance. One hundred mols of a feed mixture are to be divided into 34 mols of overhead product containing 1.0 percent of the heavy component, and 66 mols of bottoms product containing 0.73 percent of the light component. For this separation and the numbers of plates used it can be calculated that a reflux ratio of 8 to 1 will be required. It is seen that $G_C = 34 \times 0.01 = 0.34$ mols and $G_R = 66 \times 0.0073 = 0.48$ mols are the maximum amounts of impurities desired. These values are plotted on Figure 3 as shown, and the horizontal and 45° lines of G vs. B are drawn through these points as described for Figure 2. The balance plot so obtained is labeled "8/1" to correspond to the reflux ratio used. Similar plots of G vs. B as calculated for reflux ratios of 9 to 1 and 10 to 1 are also included as labeled.

The basic two-instrument system used to control this tower is shown in Figure 4. The reboiler heat input is held at a constant adjustable amount by a flow control on the heating medium. The overhead reflux is controlled by a thermocouple located midway between the feed inlet and the tower top. This arrangement uses the

multiplying effect of a number of plates to magnify a small change in product composition into a temperature change sufficient to actuate a thermocouple control. A constant feed is delivered by another operation. The products are withdrawn by liquid level controls and the pressure is held constant by a regulator, but these are not shown as they are not part of the basic control system.

Now consider what might happen when this column is brought on stream. The reboiler heat load is adjusted to correspond to an 8 to 1 reflux, the temperature control is set, and the column is allowed to line out. The analysis of the resultant overhead and bottoms product streams gives impurities of $G_C = 0.34$ and $G_R = 0.93$ mols, and these values plotted on Figure 3 give $B = +0.45$ mols as marked by line *a*. Evidently light component is being forced down the column by too much reflux. But because the overhead separation is satisfactory it might seem that no changes in the reflux control system should be made. In an attempt to improve the separation the reboiler head load is increased to correspond to a reflux ratio of 9 to 1. Product samples are analyzed and the measured impurities are found to be those shown on line *b* of Figure 3. G_R is still above the desired 0.48 mols and so the reboiler heat input is again increased to correspond to a reflux ratio of 10 to 1. The resultant measured impurities correspond to the values marked on line *c* and it is seen that the desired value of $G_R = 0.48$ mols has finally been reached. But at these conditions $G_C = 0.12$ mols, which is a much better separation than the design value of 0.34 mols.

It might be said of this column that low plate efficiencies were encountered and that increased heat throughput was required to offset these and reach the required separation. Or it might be thought that the volatility data used to calculate the reflux rate was in error. Also raising the feed inlet might be considered so that more plates would be available for the bottoms separation. Actually, of course, as seen from Figure 3, the column is simply out of balance by 0.28 mols, and if this were corrected more than adequate separations would be obtained. However, there is no assurance that the column would remain in balance.

Instead of increasing the heat duties as just described the operator of this column has another alternative. Suppose it is decided that the bottoms separation of $G_R = 0.48$ is the more important, and that a poor separation can be taken in the overhead. After the operation of line *a* has been determined the reboiler heat duty continues to correspond to a reflux ratio of 8 to 1. But the reflux control is adjusted to decrease slightly the amount of reflux so that the column becomes tilted toward too much overhead. The resulting product impurities are found to correspond to line *d* of Figure 3. The required bottoms separation of $G_R = 0.48$ is obtained, but the overhead separation is $G_C = 0.56$ instead of the desired $G_C = 0.34$. It is seen that the column is out of balance by $B = 0.22$ mols.

It will be noted that for the instrument setting of line *d* the overhead separation will vary with the balance, but the bottoms separation will remain relatively constant as long as *B* is negative. This decision to insure one sharp separation by taking a poor, varying separation in the other cut is the common solution to the problem of balance.

In addition to a continual series of small changes, most industrial installations suffer from a slow "creep", a gradual shift in the operation for a given control setting. Thus the column of Figure 3 just described could be adjusted to the exact balanced operation so that the maximum separations are obtained for the heat duties used. But suppose that the reboiler slowly fouled so that the heat input decreased slightly. With the reflux cooling held constant by the satisfactory overhead separation the column would tilt in the direction of too much bottoms, and as the reboiler continued to foul the light component lost in the bottoms would continue to increase. The column would go out of balance without a control being touched. A change in feed composition, a cold wind, etc., can also alter the balance.

Then for a control system to maintain both product purities it must hold the column in balance during a continual series of small changes in the tower operating conditions. What is the nature of the instrument arrangement that would do this? It is noted that if the reflux control is properly adjusted the column of Figure 4 would not tilt in the direction of too much overhead because the attendant temperature change would increase the reflux input and thereby drive the heavy component back down the column. Then if a similar temperature control could be applied to the bottom half of the column it could not tilt in either direction. But this lower temperature control must have something on which to act; it cannot act on the reboiler heat input as the two temperature controls would oppose each other and an unstable condition would result. If the column has a feed preheater to which the lower thermocouple can be tied then this difficulty is removed. The resulting control arrangement is shown in Figure 5.

Now consider what would happen to this column if the controls were properly adjusted for balance and the reboiler began to foul as described above. The tendency of the light component to go down the column would cause the lower thermocouple to increase the feed preheater heat input and thereby maintain the column in balance. Or if a sudden cold rain were to hit the column the preheater heat input would jump immediately to compensate for the extra heat loss. Conversely if the steam pressure on the reboiler increased and the extra heat tended to force heavy component up the column the upper thermocouple would increase the reflux to maintain the balance. Then if a column instrumented as in Figure 5 were properly adjusted for balance it would remain in balance for any changes within the capacity of the feed preheater and reflux system.

A number of other arrangements of the control instruments to maintain balance could be given. Thus for the mirror image of the control system of Figure 5 the reflux could be held constant and the feed preheater and reboiler operated from the temperature controls. Or the upper thermocouple could be used to control the temperature of a constant amount of reflux. An interesting one of these alternates will be discussed later. It is common to all of these systems that they have three major controls (constant feed and pressure are assumed) instead of the two controls usually considered simplest and most desirable (Figure 4). This corresponds to the one more variable (one product purity) brought under control. Also these controls must be carefully adjusted as they can as easily hold a system out of balance as in balance if the settings are not right.

It is of interest to note that liquid capacity can be used to balance a column. A specially arranged accumulator can do this continuously. The amount by which the column was out of balance would simply appear as a rising or falling liquid level in this accumulator.

A characteristic of balance that requires some discussion concerns the location of the near-constant zones in an operating column. These are the regions in which very little composition change takes place across a number of plates. A column with adequate

plates and giving sharp separations with close to minimum heat duties will have four of these near constant zones, one at each end of the column and one on each side of the feed inlet. The two zones above the feed inlet and the two below are separated by regions of more rapidly changing conditions.

A convenient way of representing these zones is by means of a plate temperature curve. Figure 6 is such a plot of plate numbers vs. temperature for a column distilling a binary mixture with constant heat input. Five different conditions of balance from too much bottoms to too much overhead (left to right) are shown. Curve *C* is for the exactly balanced operation, and the profile shows the four near-constant zones described above. Curves *A* and *B* show two degrees of lack of balance toward too much bottoms, and Curves *D* and *E* correspond for too much overhead. From these profiles it can be seen that when a balanced column tilts toward too much overhead the near-constant zone at the top of the column disappears and the one above the feed lengthens to include most of the plates of the section of column. The separation obtained is given by a few plates at the top of the column. Correspondingly when the column tilts toward too much bottoms the lowest near-constant zone disappears and the one below the feed inlet lengthens downward.

In general, next to the product purities themselves, an accurate temperature profile is the single most valuable thing that can be known about a column. In addition to the balance, anything from the heat duties required to the proper location of the feed inlet can be determined from such data. For a difficult and expensive distillation, the thermocouple system required for accurate plate temperatures is worth many times its cost.

One use of the plate temperature profile is in the location and setting of the two thermocouple controls in the arrangement of Figure 5. The temperature settings should be about midway between those of the constant zones on either side of the thermocouple, and the locations should be a plate or two "outside" (away from the feed inlet) the plates that have these temperatures for the balanced operation. For the distillation of Figure 6, these two control locations and temperatures are marked by the crosses near Curve *C*. Other points along the more rapidly changing part of this curve could have been used. The trick in the adjusting of these thermocouples is to prevent them from opposing each other so that increasing reflux is not countered by increasing feed preheat. One aid to this is the

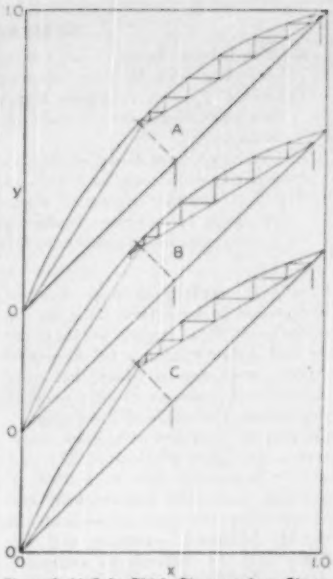


Figure 8. McCabe-Thiele Diagrams for a Binary Distillation. A is the original design, B is the actual tilted operation, and C is a plate count calculation such as might be made.

location of the control setting slightly "outside" of the balanced plate temperature curve as described above. Another help is to have different rates of correction in the two temperature controls. Thus the preheater control could be fast acting and the reflux control comparatively slow acting.

From Figure 6, it can be seen that when the column tilts toward too much overhead the temperature increases for the upper thermocouple control and approximately holds constant for the lower one. And when the column tilts toward too much bottoms the lower thermocouple control drops in temperature and the upper one holds constant. This can be made the basis of the very interesting control arrangement shown on Figure 7. The reflux cooling and the reboiler heat are held constant by flow controllers. The heat input to the feed preheater is controlled by the sum of the temperatures of the two thermocouples. For such a system, if the column tilted toward too much overhead, the temperature increase of the upper control thermocouple (the lower remaining constant) would decrease the heat into the feed and so balance the column. And if the column tilted toward too much bottoms the temperature drop of the lower thermocouple (the upper one remaining constant) would increase the heat input to the feed and return the column to balance.

In recent years, there has been a considerable amount of work done on plate efficiencies, and this has had the purpose of correlating plate details and fluid properties with the resulting amount of vapor-liquid contacting obtained. This amount of contacting is commonly determined by calculating a number of equilibrium plates required to give the measured product purities. The ratio of required to actual plates is called the plate efficiency. The correlations developed have, in general, been unsatisfactory, and in attempting to overcome this unusual combination of variables have been tried.

It is believed that the principal reason for the difficulties of these correlations has been the failure to distinguish between plate efficiencies and column balance as causes of poor separations. A column held out of balance will necessarily give one poor separation which will require only a few equilibrium plates, and this number will be independent of the amount of contacting that is actually present. Because of this it is characteristic in plate efficiency determinations in which an actual feed plate composition is used that one half of the tower gives a much lower calculated efficiency than the other half. In determining plate efficiencies, the number of equilibrium plates used is the minimum required for the separation, and additional plates may be present in near-constant zones without measurably affecting the product compositions. This, of course, results in abnormally low calculated plate efficiencies. The analogous use of minimum numbers of plates based on incomplete methods of calculation is believed to be the reason for the low plate efficiencies commonly assigned to natural gasoline absorbers.[1]

A simplified example of how plate efficiency and balance can be confused is shown on the three McCabe-Thiele diagrams of Figure 8. Diagram *A* represents the original design for a binary distillation in which a 98 percent pure overhead product is obtained with eight equilibrium plates above the feed. When the column was tested, it was slightly tilted in the direction of too much overhead so that the overhead purity obtained was only 96 percent. The resulting operation is given by Diagram *B*, which shows that a part of the eight plates present form a near-constant zone at the feed. But, if the number of equilibrium plates were calculated by the usual means from the product composition, the result would be as shown by Diagram *C*. It is seen that only seven plates

are required to give the 96 percent purity. Then, if there were 10 actual plates, the calculated plate efficiency would be 70 percent instead of the true 80 percent. For commercial columns with their large numbers of plates, the effect of balance can be much greater than shown in this example so that errors of 100 percent in the calculated plate efficiency are easily possible.

It is quite true that the separations obtained, the heat duties used, and the properties of the components mathematically fixes the number of equilibrium plates present. But for columns with reasonably large numbers of plates, the accuracy required for these calculations to have any meaning is extreme. Neither the basic data nor the methods used can possibly be made accurate enough to permit the calculation of the number of plates in a near-constant zone of any length. For the column of Figure 8, no heat balance could be made exact enough to distinguish between the slopes of the upper operating lines of Diagrams *B* and *C*. Then, it can be concluded that for most commercial columns, it is impossible to calculate reliable plate efficiencies based on data from the ends of the column only.

A convenient and quick way of determining the actual plate efficiencies can be based on an accurate temperature profile of the operating column. Equilibrium plate-to-plate calculations are made for a few plates in the part of the column for which the temperature curve is changing most rapidly. The overall plate efficiency is simply the ratio of the slopes of the two temperature curves. For Murphree type efficiencies, a trial and error arrangement can be used. The correct Murphree efficiency, when used in the plate-to-plate procedure, gives a plate temperature curve of the same slope as the measured one. Compositions instead of temperatures can be used if they are available, and these give more accurate results.

It is surprising that so little appears in the literature concerning a problem as expensive and troublesome and as widely recognized as column balance. This is in contrast with the present intensive study of plate efficiencies[5]. As a result of this lack, there are some to whom the idea that a controlled, smoothly running column could be giving a poor separation for such an elementary reason is astonishing. A partial explanation of this may be the fact that the theory developed for distillation and any calculations based thereon are always for columns that are nicely balanced.

There are certain difficulties involved in the study of balance and these may explain in part why so little seems to have been done on the subject. A first reason is that the column balance cannot be measured directly with any accuracy, but only indirectly by means of the product impurities. The cause of these impurities may be confused with other causes such as low plate efficiencies. The part of the impurities due to a lack of balance cannot be known with certainty except by comparison with the exactly balanced operation, and this latter may be difficult to recognize. A second difficulty is that the change in balance accompanying a change in the tower operation is a complex function of the characteristics of the control instruments. Then any adjustment of the balance by changing the control settings is necessarily trial and error. Thus in the example operation, the locations of lines *a* to *d* of Figure 3 could not have been predicted in advance.

A third and major difficulty in the study of balance is simply what to do about it. There is no point in elaborately adjusting a column if the control system is such that it cannot be kept in balance. As previously stated, it is believed that the solution lies in the arrangement and proper adjustment of the control instruments.

In rough distillation such as the topping of crude oil, the balance is controlled simply by adjusting the cut temperature, and is no problem. But with increasing sharpness of separation, the balance becomes more and more important. Thus for a column separating a 50-50 binary mixture into 96 percent pure product streams (2 mols of impurity in each product), a value of $B = \pm 2.0$ will make the separation impossible. But, if 98 percent purities are desired, a value of one-half as much or $B = \pm 1.0$ will make them impossible. This increasing effect of balance with increasing difficulty of the separation may be the source of the reported connection[6] between plate efficiency and the "relative volatility", i.e. the ratio of the velatilities of the key components. For equal product impurities due to a lack of balance, an easy separation (high relative volatility) would lead to fewer calculated plates and lower plate efficiencies than a more difficult separation (lower relative volatility).

A separation purity also becomes more sensitive to balance as the product stream becomes a smaller percentage of the feed. Thus, for a binary split of 25 mols overhead—75 mols bottoms, a balance of $B = -1.0$ would make an overhead purity of 96 percent impossible. This is a partial explanation of the unsatisfactory purities sometimes obtained for components present in small amounts. According to the theory such products should be obtained in as high purity as those present in greater amounts.

One result of the concept of balance is that the body of theory developed for distillation becomes directly applicable to the commercial operations. With the inclusion of balance among the distillation variables, the theoretical-actual differences, which otherwise seem so irregular and unpredictable, largely disappear. The difficult separations vs. heat duties relations of the actual columns fall in line to a surprising degree. This results in confidence in the whole theory structure and in the accuracy with which it can be applied to a specific case. With the removal of the chance of balance, the close economic design and operation of the column becomes feasible. A much closer approach to the minimum heat duties can be used. The failure to control balance in commercial columns is believed to be the principal reason for the existence of the substantial group who distrust the theory and feel that the only "safe" way to design a distillation operation is by the extension of data from existing plants.

NOMENCLATURE

B The balance factor, a measure of the column balance. Defined as $B = V°_c - V_c$. Mols per 100 mols feed.

G_c and G_R Product impurities. Heavy components in the condenser product and light components in the reboiler product respectively. Mols per 100 mols feed.

K Averaged vapor-liquid equilibrium constant ($y = Kx$).

P Fraction of a component that goes to the overhead product.

$V°_c$ The optimum amount of the overhead product for the exact balanced operation of maximum product purities. Mols per 100 mols feed.

V_c The actual amount of the overhead product. Mols per 100 mols feed.

REFERENCES

[1] Atkins, G. T., and Franklin, W. B., Petroleum Refiner, 15, P. 30 (1936).

[2] Boyd, D. M., Jr., Petroleum Refiner, 27, No. 10, p. 533; No. 11, 595 (1948).

[3] Harbert, W. D., Petroleum Refiner, 27, No. 10, p. 512 (1948).

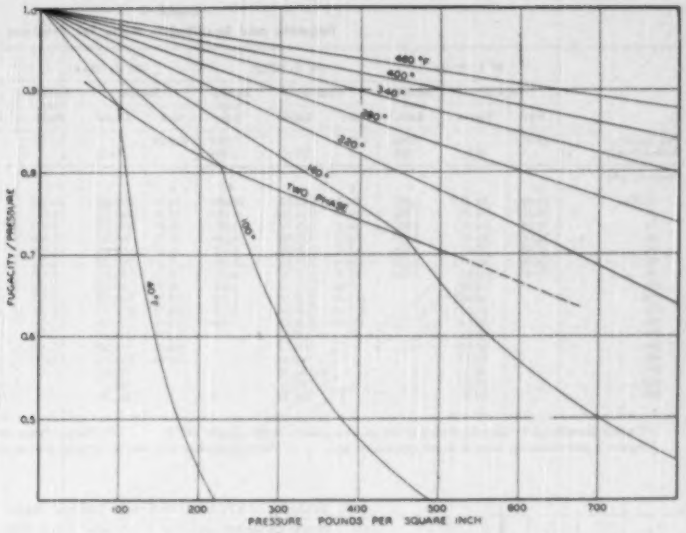
[4] O'Connell, H. E. Trans. Am. Inst. Chem. Engrs. 42, p. 741 (1946).

[5] Pigford, R. L., and Colburn, A. P. "Plate Efficiencies for Distillation Columns," p. 610, 3rd Edition. Perry's Chemical Engineers Handbook" (McGraw-Hill Book Co.)

[6] Rector, K. K., Petroleum Processing, 4, p. 525 (1949).

[7] William, G. C., Stigger, E. K., and Nichols, J. H., Chem. Eng. Progress, 46, p. 7 (1950).

Figure 1. ——→
Fugacity of propene at the lower pressures.



The Fugacity of Propene and 1-Butene

B. H. SAGE and W. N. LACY
California Institute of Technology, Pasadena

THE INCREASING utilization of conversion processes in refineries and gasoline plants requires engineers to make calculations involving olefins and utilizing data on the volumetric and phase behavior of these hydrocarbons. From experimental information concerning the vapor pressure and the influence of temperature and pressure upon the specific volume of propene and 1-butene, the fugacity has been computed for the liquid and gas phases at pressures up to 10,000 psi. in the temperature interval from 40° to 340° F. and from 100° to 340° F., respectively. The fugacities of these compounds were estimated for the gas phase at pressures above vapor pressure and for the liquid phase at pressures below it. Corresponding values for n-butane were calculated for comparison. From these data, upon the basis of ideal solution behavior and of predictions from Raoult's and Dalton's laws, the equilibrium constants were calculated for these compounds at pressures up to 800 psi. in the temperature intervals between 40° to 280° F. and 100° to 280° F., respectively. The values are compared with published data for the 1-butene—n-butane system.

INDUSTRIAL interest in the olefin hydrocarbons and in their separation from other materials has made desirable a knowledge of the volumetric and phase behavior of these unsaturated hydrocarbons and their mixtures. Values of vapor pressure and the influence of pressure and temperature upon the specific volume of propene and 1-butene were established recently.[4, 9] These measurements were made at pressures up to 10,000 psi. in the temperature interval from 40° to 460° F. and 100° to 340° F., respectively. The data permit the calculation of the fugacity[7] of propene and 1-butene over the above-mentioned ranges of pressure and temperature.

The fugacity[7] is defined by the equations,

$$b_k T \ln f_k = \mu_k - \beta \qquad (1)$$

$$\frac{f_k^*}{P} \rightarrow 1, \quad P \rightarrow 0 \qquad (2)$$

The fugacity of a pure component may be established from the relation,

$$\ln \frac{f_k^*}{P} = -\frac{1}{b_k T} \int_0^P \underset{\sim}{V}_k \, dP \qquad (3)$$

The residual volume indicated in Equation (3) is related to the prevailing pressure and specific volume by the expression,

$$\underset{\sim}{V}_k = \frac{b_k T}{P} - V_k \qquad (4)$$

Equation (3) is particularly useful in establishing the fugacity of a pure component in the gas phase. In the case of a liquid it is more convenient to employ the following expression:

TABLE 1

Fugacity and Equilibrium Ratio for Propene

	60° F. (97.5)[a]			100° F. (227.3)			160° F. (456.6)			220° F.			280° F.		
	Fugacity[a]		Equilibrium[b] Ratio	Fugacity		Equilibrium Ratio	Fugacity		Equilibrium Ratio	Fugacity		Equilibrium Ratio	Fugacity		Equilibrium Ratio
	Gas	Liquid		Gas	Liquid		Gas	Liquid		Gas	Liquid		Gas	Liquid	
Dew Point	85.91	.....	1.000	183.45	.....	1.000	329.22	.....	.....	.....	.....	.....	.....	.....	.....
Bubble Point	.....	85.91	1.000	.....	183.45	1.000	.....	329.22	.....	.....	.....	.....	.....	.....	.....
Pressure, psia.:															
0	0		∞	0		∞	0		∞	0		∞	0		∞
14.696	14.44	[84.27][c]	5.837	14.51	[174.52]	12.030	14.56	[292.45]	20.082	14.60	[460.37]	31.543	14.62	[646.05]	44.196
20	19.52	[84.38]	4.323	19.66	[174.65]	8.884	19.76	[292.98]	14.831	19.82	[460.92]	23.255	19.86	[647.01]	32.574
30	28.92	[84.60]	2.925	29.23	[175.14]	5.991	29.45	[293.73]	9.974	29.59	[461.98]	15.613	29.69	[648.92]	21.856
40	38.06	[84.80]	2.227	38.64	[175.55]	4.544	39.02	[294.50]	7.550	39.27	[463.03]	11.790	39.45	[650.79]	16.496
50	47.00	[85.01]	1.809	47.87	[176.02]	3.677	48.47	[295.48]	6.096	48.88	[464.09]	9.498	49.14	[652.71]	13.283
60	55.66	[85.21]	1.531	56.94	[176.43]	3.099	57.80	[296.30]	5.126	58.35	[465.15]	7.972	58.77	[654.58]	11.139
90	72.25	[85.61]	1.166	74.57	[177.27]	2.378	76.10	[298.01]	3.916	77.09	[467.28]	5.931	77.81	[659.41]	8.475
100	.....	85.96	.....	91.53	178.13	1.946	93.91	299.59	3.190	95.46	469.40	4.917	96.57	661.25	6.847
125	.....	86.46	.....	111.80	179.14	1.602	115.50	301.67	2.612	117.94	472.08	4.003	119.66	667.13	5.575
150	.....	86.97	.....	131.00	180.24	1.376	136.33	303.77	2.228	139.83	474.78	3.395	142.32	671.99	4.722
200	.....	87.98	.....	166.33	182.35	1.096	175.76	308.09	1.753	181.98	480.22	2.639	185.39	680.71	3.652
250	.....	89.01	.....	.....	186.43	.....	212.21	312.27	1.472	221.93	485.72	2.189	228.81	691.50	3.022
300	.....	90.05	.....	.....	186.57	.....	245.62	316.55	1.289	259.70	491.25	1.902	269.57	701.36	2.602
400	.....	92.16	.....	.....	190.92	.....	302.96	[324.78]	1.072	328.68	502.69	1.529	346.23	722.28	2.095
500	.....	94.30	.....	.....	195.36	.....	.....	332.84	.....	388.86	514.50	1.323	416.49	741.60	1.788
600	.....	96.50	.....	.....	199.87	.....	.....	341.17	.....	440.35	[526.40]	1.195	480.84	[760.86]	1.582
800	.....	101.03	.....	.....	209.12	.....	.....	357.96	.....	510.69	.....	.....	590.96	.....	.....

[a] Fugacity is estimated for the critical state at 427 psi. at a pressure of 666 psi. and 197° F. [b] Equilibrium ratios were obtained by use of the relation $K = f'_{L_A}/f'_{G_A}$.
[c] Figures in parentheses are vapor pressures expressed in psia. [d] Values in brackets were obtained by extrapolation and represent unstable states

$$\ln \frac{f''_{L,i}}{f''_{G,i}} = \frac{1}{RT} \int_{P''_i}^{P} V_i \, dP \qquad (5)$$

The foregoing equations were applied in conjunction with the volumetric data for propene[4] and l-butene[5] to establish the fugacity as a function of temperature and pressure. The integrations were accomplished by residual graphical operations with an uncertainty of not more than 0.1 percent.

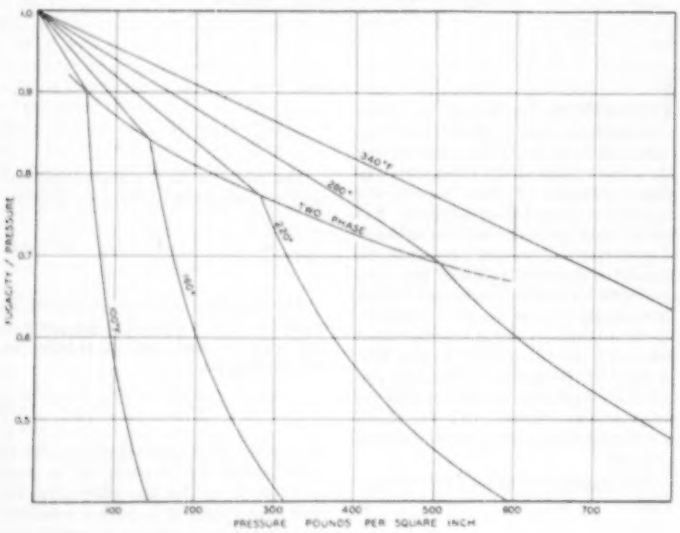
In Table 1 is recorded the fugacity of propene whereas similar information for l-butene constitutes Table 2. For purposes of comparison and for use here in calculations for a binary system, corresponding values have been determined for *n*-butane upon the basis of earlier volumetric measurements.[6] They are presented in Table 3. These data are limited to a maximum pressure of 800 psi. and a maximum temperature of 280° F. The fugacity of the liquid phase at pressures below vapor pressure and that of the gas phase at pressures somewhat above vapor pressure have been included. The latter information was obtained by direct extrapolation of the fugacity of the liquid phase to the lower pressures and by extrapolation of the ratio of the fugacity of the gas phase to the pressure to values above vapor pressure. These estimated values of fugacities for phases that are not stable in the pure state have been placed in brackets. Equilibrium constants (perhaps better called equilibrium ratios) applicable to ideal solutions[7] have been included in Tables 1 and 2. These were computed from the recorded values of the fugacity by application of the following expression:

$$K_i = \frac{Y_i}{X_i} = \frac{f''_{L,i}}{f''_{L,i}} \qquad (6)$$

The fugacities of the liquid and gas phases indicated in Equation (6) apply to the same pressure and temperature and therefore involve a value for one phase at a stable state and for the other at an unstable state, obtained by extrapolation. The data for the stable phases are not believed to involve uncertainties greater than 0.3 percent. However, the estimated values of the fugacity of the unstable phases may involve uncertainties as large as 4 percent. The magnitude of this uncertainty increases nearly directly with the magnitude of the difference in pressure between the state in question and the state at which the phase involved would be stable.

In Tables 4 and 5 are presented the fugacities of propene and l-butene at pressures from 1000 to 10,000 psi. in the temperature intervals from 40° to 460° F. and 100° to 340° F. In this instance only the fugacity of the stable phase has been included. It is believed that these values do not involve uncertainties greater than 0.5 percent. As a matter of interest the ratio of the fugacity to the pressure for propene and l-butene in the gas phase has been presented graphically in Figures 1 and 2 while the ratio of the fugacity of the

Figure 2. Fugacity of 1-Butene at the Lower Pressures.



liquid phases of these compounds to the fugacity at bubble point is depicted in Figures 3 and 4. The fugacity of propene and l-butene at bubble point for each of the temperatures indicated in Figures 3 and 4 may be obtained from Tables 1 and 2, respectively.

The data presented in Tables 1 and 2 were employed earlier to predict the behavior of the propene—l-butene system,[6] which was then compared with that of an ideal solution[7] and of a set of coexisting phases following the laws of Raoult[10] and Dalton. It appears that the propene—l-butene system approximates an ideal solution except in the critical region but deviates markedly in behavior from the laws of Raoult and Dalton.

The phase behavior of the l-butene—*n*-butane system has been investigated over a limited range of conditions[11] and affords another opportunity to check the applicability of ideal solutions in describing the phase behavior of hydrocarbon systems involving olefins. Such a relationship would be expected to apply only at relatively low pressures. In Table 6 are presented equilibrium constants for the l-butene—*n*-butane system as determined experimentally, established from the laws of Raoult and Dalton, and predicted from ideal solutions. The equilibrium constants for *n*-butane based upon Raoult's and Dalton's laws were obtained from recent vapor pressure measurements[8] which agree well with the earlier studies of Beattie, et al.[1,2] The behavior of this compound in an ideal solution was calculated from the fugacity values contained in Table 3. The corresponding values for l-butene were computed from available vapor pressure data[9] and the equilibrium constants recorded in Table 2.

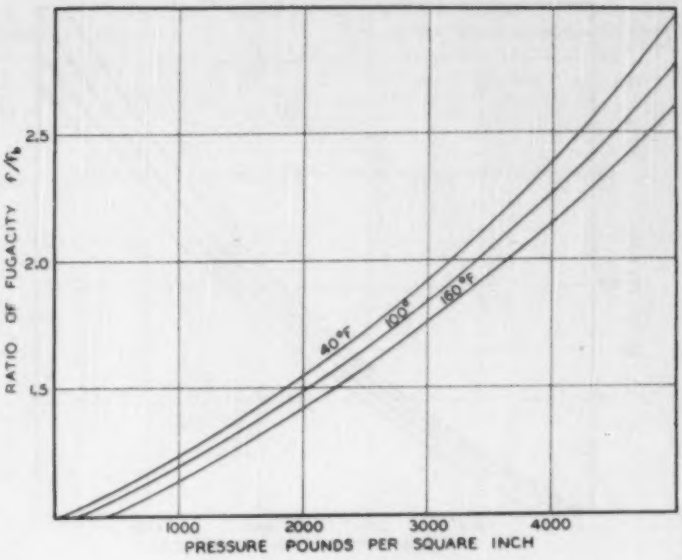


Figure 3. Fugacity of Propene at High Pressures

Figure 5 shows the ratio of the experimental equilibrium constant of l-butene in the l-butene—*n*-butane system to those predicted from ideal solutions and from Raoult's and Dalton's laws. Figure 6 makes a similar comparison for *n*-butane. As in the case of the propene—l-butene system,[6] the l-butene—*n*-butane system[11] appears to conform more nearly to an ideal solution than to Raoult-Dalton behavior.

The Gibbs-Duhem relationship[3,5] when applied to the coexisting phases of a binary system which follow the laws of Raoult and Dalton may assume the following form:[6]

$$\frac{d\ln \frac{Y_i P}{X_i P_i^{\circ}}}{dX_i} n_i = \frac{d\ln \frac{Y_{iv} P}{X_{iv} P_{iv}^{\circ}}}{dX_{iv}} n_{iv} = \frac{d\ln \frac{K_i}{K_{R,i}}}{dX_i} n_i = \frac{d\ln \frac{K_{iv}}{K_{R,iv}}}{dX_{iv}} n_{iv} \quad (7)$$

The same expression applied to a binary heterogeneous system of ideal solution leads[6] to

$$\frac{d\ln \frac{Y_i f^{\circ}_{g,i}}{X_i f^{\circ}_{\ell,i}}}{dX_i} n_i = \frac{d\ln \frac{Y_{iv} f^{\circ}_{g,iv}}{X_{iv} f^{\circ}_{\ell,iv}}}{dX_{iv}} n_{iv} = \frac{d\ln \frac{K_i}{K_{f,i}}}{dX_i} n_i = \frac{d\ln \frac{K_{iv}}{K_{f,iv}}}{dX_{iv}} n_{iv} \quad (8)$$

The average deviation of the l-butene—*n*-butane system from Equation (7) expressed in terms of Briggs logarithms for mole fractions of l-butene between 0.2 and 0.8 for the liquid phase is —0.0596 for 100° F. and —0.0753 for 160° F. The deviations of the l-butene—*n*-butane system from the behavior described by Equation (8) at mole fractions of l-butene in the liquid phase between 0.2 and 0.8 were —0.0090 and —0.0042 for temperatures of 100° and 160° F., respectively. This information is con-

TABLE 2
Fugacity and Equilibrium Ratio of 1-Butene

	100° F. (62.5)[c]			160° F. (142.9)			220° F. (282.6)			280° F. (506.8)		
	Fugacity[a]		Equilibrium[b] Ratio	Fugacity		Equilibrium Ratio	Fugacity		Equilibrium Ratio	Fugacity		Equilibrium Ratio
	Gas	Liquid		Gas	Liquid		Gas	Liquid		Gas	Liquid	
Dew Pt.	56.30	.....	1.000	120.16	.....	1.000	218.58	.....	1.000	350.23	.....	1.000
Bubble Point	.....	56.30	1.000	.....	120.16	1.000	.....	218.58	1.000	.....	350.23	1.000
Pressure, psia.												
0	0	.....	∞	0	.....	∞	0	.....	∞	0	.....	∞
14.696	14.35	[55.59][d]	3.873	14.45	[116.02]	8.029	14.52	[202.58]	13.955	14.56	[298.99]	20.528
20	19.36	[55.67]	2.876	19.54	[116.12]	5.941	19.67	[202.91]	10.316	19.76	[299.48]	15.160
30	28.57	[55.83]	1.954	28.98	[116.80]	4.030	29.26	[203.61]	6.959	29.45	[301.06]	10.222
40	37.46	[55.96]	1.494	38.19	[117.80]	3.056	38.68	[204.13]	5.277	39.03	[302.60]	7.753
50	46.03	[56.12]	1.219	47.18	[117.10]	2.482	47.95	[204.70]	4.269	48.48	[303.65]	6.263
60	54.28	[56.28]	1.037	55.94	[117.46]	2.100	57.05	[205.31]	3.599	57.82	[305.68]	5.287
80	[69.73]	56.56	0.811	72.82	[118.09]	1.622	74.78	[206.56]	2.762	76.10	[308.73]	4.030
100	[83.99]	56.85	0.677	88.82	[118.76]	1.337	91.86	[207.71]	2.261	93.95	[307.75]	3.276
125	[100.06]	57.23	0.572	107.58	[119.56]	1.111	112.34	[209.18]	1.862	115.56	[310.30]	2.685
150	[114.08]	57.61	0.505	[124.95]	120.38	0.962	131.84	[210.69]	1.598	136.45	[313.10]	2.295
200	[136.30]	59.37	0.438	[155.40]	121.96	0.785	168.05	[213.73]	1.272	175.98	[318.18]	1.809
250	.....	59.14	.....	[180.42]	123.54	0.685	199.98	[216.61]	1.083	212.84	[323.54]	1.520
300	.....	59.92	.....	[199.80]	125.15	0.626	[227.94]	219.58	0.963	246.45	[328.76]	1.334
400	.....	61.50	.....	[222.04]	128.42	0.578	[271.84]	225.51	0.830	304.37	[339.34]	1.118
500	.....	63.13	.....	.....	131.75	.....	[299.50]	231.52	0.773	348.02	[349.77]	1.005
600	.....	64.79	.....	.....	135.16	.....	[311.34]	237.66	0.763	[384.18]	360.35	0.938
800	.....	68.24	.....	.....	142.29	.....	.....	250.27	.....	.....	381.43	.....

[a] Fugacity is estimated for the critical state at 295 psi. at a pressure of 558 psi. and 297° F.
[b] Equilibrium ratios were obtained by use of the relation $K = f^{\circ}_{l,i}/f^{\circ}_{g,i}$.
[c] Figures in parentheses are vapor pressure expressed in psia.
[d] Values in brackets were obtained by extrapolation and represent unstable states.

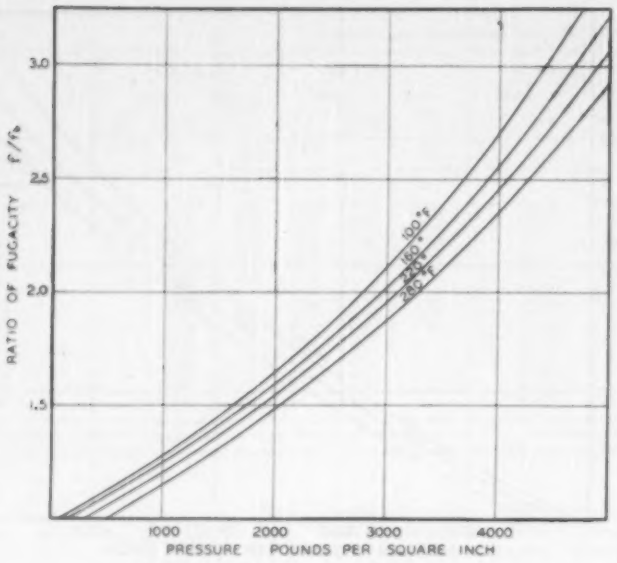
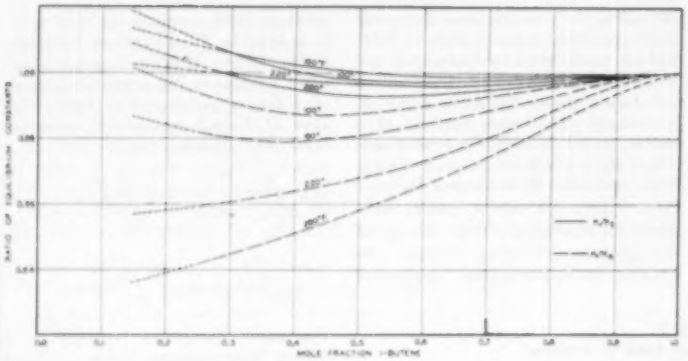


Figure 4. Fugacity of 1-Butene at High Pressures.



← Figure 5.
Ratio of Equilibrium Constant for 1-Butane in the 1-Butene-n-Butane System.

sistent with the earlier statements as to the relatively good agreement of the 1-butene—*n*-butane system with ideal solutions in the temperature interval between 100° and 220° F. and emphasizes that substantial deviations from the laws of Raoult and Dalton exist.

ACKNOWLEDGMENT

The assistance of Betty Kendall and Virginia Berry in connection with the calculation of the values presented is acknowledged.

LITERATURE CITED

[1] Beattie, J. A., Simard, G. L., and Gouq-Jen Su, J. Am. Chem. Soc., **61**, 24-6 (1939).
[2] Ibid., **61**, 26-7 (1939).
[3] Duhem, P., Compt. rend., **102**, 1449-51 (1886).
[4] Farrington, P. S., and Sage, B. H., Ind. Eng. Chem., **41**, 1734-7 (1949).
[5] Gibbs, J. W., "Collected Works of," Vol. I, Thermodynamics, New York, Longmans, Green and Co., 1931.
[6] Goff, G. H., Farrington, P. S., and Sage, B. H., "Volumetric and Phase Behavior of the Propene—1-Butene System," In Press, Ind. Eng. Chem.

(Continued on next page)

NOMENCLATURE

- $\mathfrak{b}$ = specific gas constant, $\mathfrak{b} = R/M$
- d = total differential
- f = fugacity, lb./in.²
- K = equilibrium constant or equilibrium ratio
- $\ln$ = natural logarithm
- n = mole fraction of component in a phase or system
- P = pressure, lb./in.² absolute
- P'' = vapor pressure, lb./in.²
- T = thermodynamic temperature, °R.
- V = specific volume, cu. ft./lb.
- $\underset{\sim}{V}$ = residual specific volume, cu. ft./lb.
- X = mole fraction of component in the liquid phase
- Y = mole fraction of component in the gas phase
- β = a constant for any one temperature
- $\int$ = definite integral
- μ = chemical potential of component, Btu./lb.

Superscripts:

- ^{o} = a pure substance
- $''$ = two phases

Subscripts:

- b = bubble point
- d = dew point
- g = gas phase
- I = ideal solution
- k = component k
- l = liquid phase
- R = basis of Raoult's and Dalton's laws
- 4 = *n*-butane
- IV = 1-butene

Figure 6.
Ratio of Equilibrium Constants for n-Butane in the 1-Butene-n-Butane System.

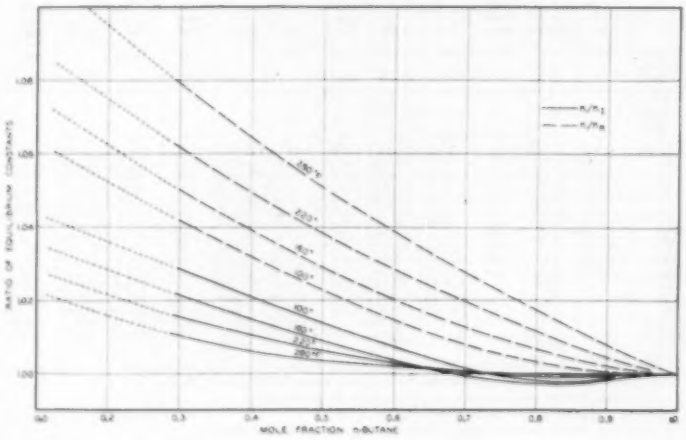


TABLE 3

Fugacity and Equilibrium Ratio of n-Butane

	100° F. (51.5)[c]			160° F. (120.6)			220° F. (241.2)			280° F. (436.6)		
	Fugacity[a]		Equilibrium[b] Ratio	Fugacity		Equilibrium Ratio	Fugacity		Equilibrium Ratio	Fugacity		Equilibrium Ratio
	Gas	Liquid		Gas	Liquid		Gas	Liquid		Gas	Liquid	
Dew Pt.	47.15	.....	1.000	102.92	.....	1.000	187.94	.....	1.000	303.60	.....	1.000
Bubble Point	.....	47.15	1.000	.....	102.92	1.000	.....	187.94	1.000	.....	303.60	1.000
Pressure, psia												
0	0	0	∞	0	0	∞	0	0	∞	0	0	∞
14.696	14.34	[46.65]	3.253	14.43	[99.94]	6.926	14.50	[176.10]	12.14	14.84	[264.41]	18.18
20	19.35	[46.72]	2.415	19.51	[100.12]	5.132	19.63	[176.40]	8.986	19.71	[264.65]	13.43
30	28.53	[46.87]	1.643	28.80	[100.39]	3.474	29.16	[176.91]	6.067	29.36	[265.29]	9.036
40	37.38	[47.00]	1.257	38.05	[100.67]	2.646	38.51	[177.43]	4.607	38.86	[266.47]	6.857[c]
50	45.90	[47.13]	1.027	45.96	[100.95]	2.150	27.68	[177.96]	3.732	48.22	[267.41]	5.546
60	[54.11][d]	47.27	0.874	55.62	[101.23]	1.820	56.67	[178.48]	3.150	57.44	[268.35]	4.672
80	69.50	47.53	0.678	72.23	[101.78]	1.409	74.09	[179.50]	2.423	75.47	[270.20]	3.580
100	83.90	47.79	0.580	87.86	[102.34]	1.165	90.78	[180.57]	1.989	92.94	[272.15]	2.928
125	[99.41]	48.12	0.484	[108.06]	103.04	0.972	110.64	[181.87]	1.644	114.00	[274.45]	2.407
150	[113.18]	48.46	0.428	[122.70]	103.74	0.845	129.36	[183.18]	1.416	134.22	[276.79]	2.062
200	[134.50]	49.14	0.365	[151.50]	105.16	0.694	163.40	[185.78]	1.137	172.07	[281.50]	1.636
250	.....	49.83	.....	[174.25]	106.59	0.612	[192.62]	188.41	0.978	206.52	[286.11]	1.385
300	.....	50.52	.....	[190.95]	108.05	0.566	[217.50]	191.02	0.878	237.55	[291.00]	1.235
400	.....	51.93	.....	[206.40]	111.01	0.528	[253.40]	196.36	0.775	288.98	[300.29]	1.039
500	.....	53.38	.....	.....	114.03	.....	[271.20]	201.79	0.744	[326.00]	[309.64]	0.950
600	.....	54.86	.....	.....	117.13	.....	.....	207.31	.....	[349.50]	319.02	0.913
800	.....	57.95	.....	.....	123.53	.....	.....	218.67	.....	.....	337.85	.....

[a] Fugacity is estimated for the critical state at 362 psi. at a pressure of 550.66 psi. and 305.62° F.

[b] Equilibrium ratios were obtained by use of the relation $K = f'_{n1} / f_{n1}$.

[c] Figures in parentheses are vapor pressures expressed in psia.

[d] Values in brackets were obtained by extrapolation and represent unstable states.

TABLE 5

Fugacity of 1-Butene at Higher Pressures

Pressure psia.	100° F.	160° F.	220° F.	280° F.	340° F.
1000	71.85[a]	140.34	262.34	402.60	547.52
1250	76.61	150.20	280.53	430.12	591.09
1500	81.06	160.37	298.81	456.50	634.47
1750	87.00	180.12	317.28	488.29	678.75
2000	92.68	191.46	337.22	519.32	724.20
2250	98.52	203.43	358.07	551.71	771.37
2500	105.08	216.06	379.98	585.58	820.17
2750	111.85	229.38	402.99	621.02	870.69
3000	119.08	243.44	427.21	658.08	923.05
3500	134.69	273.95	479.43	737.84	1036.08
4000	152.31	307.94	537.22	824.79	1158.58
4500	172.09	345.79	601.16	920.68	1292.30
5000	194.25	387.92	671.93	1026.20	1438.32
6000	247.08	487.04	836.91	1269.98	1772.43
7000	313.44	609.64	1038.81	1564.93	2172.25
8000	396.66	761.05	1285.37	1921.39	2656.64
9000	500.93	947.82	1585.76	2351.43	3222.3
10,000	716.95	1177.76	1951.05	2869.14	3903.5

a. Expressed in pounds per square inch absolute.

TABLE 4

Fugacity of Propene at Higher Pressures

Pressure, psia.	40° F.	100° F.	160° F.	220° F.	280° F.	340° F.	400° F.	460° F.
1000	105.75	218.68	375.05	546.94	677.22	753.70	809.53	849.50
1250	111.92	231.19	397.08	583.29	758.63	873.93	950.55	1019.72
1500	118.41	244.25	419.86	619.73	820.49	976.19	1093.62	1177.28
1750	125.24	257.92	443.50	656.43	877.26	1067.01	1215.65	1324.72
2000	132.42	272.21	468.12	694.82	933.60	1151.30	1329.98	1464.15
2250	139.98	287.18	493.74	733.94	990.38	1233.03	1438.76	1598.03
2500	147.93	302.86	520.40	774.19	1048.73	1313.10	1544.30	1728.82
2750	156.31	319.30	548.22	815.56	1108.45	1393.37	1648.61	1856.53
3000	165.11	336.51	577.23	858.38	1170.34	1474.40	1753.13	1983.60
3500	184.12	373.46	639.06	950.23	1298.08	1642.66	1965.35	2239.35
4000	205.15	414.06	706.35	1049.42	1434.48	1819.94	2185.48	2502.98
4500	228.42	458.58	779.70	1156.67	1580.76	2008.16	2414.40	2774.40
5000	254.13	507.49	859.57	1272.63	1737.86	2208.78	2658.94	3060.8
6000	313.98	620.08	1041.50	1533.99	2088.66	2651.88	3193.8	3683.3
7000	387.01	758.87	1257.20	1840.53	2498.04	3166.2	3801.5	4402.4
8000	476.02	918.79	1513.24	2200.15	2967.14	3744.7	4492.9	5196.2
9000	584.58	1114.01	1816.62	2621.75	3515.1	4416.3	5281.8	6074.7
10,000	715.86	1341.82	2175.60	3114.9	4149.9	5189.5	6182.4	8855.6

TABLE 6

Comparison of Equilibrium Ratios of 1-Butene and n-Butene

	1-Butene			n-Butene		
Pressure, psia.	Experimental[a]	Ideal	Raoult's Law	Experimental	Ideal	Raoult's Law
100° F.:				1.000	1.000	1.000
51.5[b]				0.960	0.963	0.959
53.7	1.160	1.144	1.164	0.935	0.925	0.916
56.2	1.098	1.099	1.112	0.915	0.893	0.880
58.5	1.057	1.060	1.068	0.895	0.866	0.850
60.6	1.028	1.038	1.031			
62.5[c]	1.000	1.000	1.000			
160° F.:				1.000	1.000	1.000
120.6[b]				0.969	0.972	0.965
125.0	1.125	1.111	1.142	0.948	0.943	0.929
129.8	1.078	1.078	1.101	0.930	0.918	0.897
134.6	1.047	1.048	1.063	0.920	0.896	0.869
138.8	1.020	1.020	1.030			
142.9[c]	1.000	1.000	1.000			
220° F.:				1.000	1.000	1.000
241.2[b]				0.979	0.979	0.967
249.4	1.085	1.086	1.133	0.962	0.959	0.936
257.7	1.056	1.061	1.097	0.950	0.941	0.907
266.0	1.033	1.040	1.062	0.945	0.924	0.879
274.3	1.014	1.019	1.030			
282.6[c]	1.000	1.000	1.000			
280° F.:				1.000	1.000	1.000
436[b]				0.986	0.987	0.969
450	1.055	1.060	1.124	0.975	0.974	0.939
464	1.038	1.036	1.091	0.970	0.964	0.912
478	1.020	1.027	1.059	0.970	0.953	0.886
492	1.008	1.012	1.028	.....	.....	.....
505[c]	1.000	1.000	1.000			

[a] Experimental values based on 1-Butene—n-Butene system.

[b] Vapor pressure of n-Butane. [c] Vapor pressure of 1-Butene.

REFERENCES (Continued)

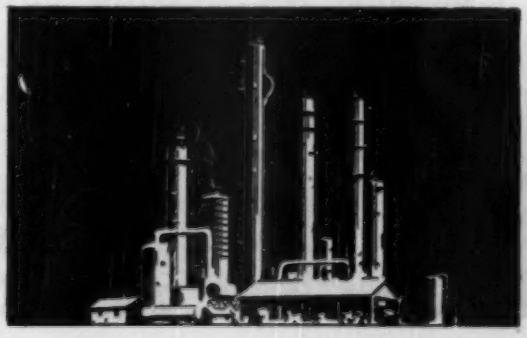
[7] Lewis, G. N., J. Am. Chem. Soc., **30**, 668-83 (1908).

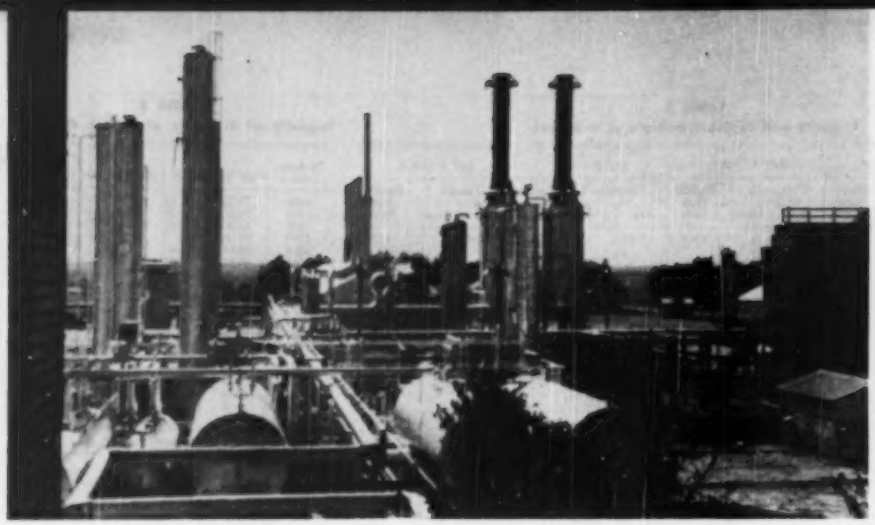
[8] Olds, R. H., Reamer, H. H., Sage, B. H., and Lacey, W. N., Ind. Eng. Chem., **36**, 282-4 (1944).

[9] Olds, R. H., Sage, B. H., and Lacey, W. N., Ibid., **38**, 301-3 (1946).

[10] Raoult, F. M., Z. physik. Chem., **2**, 353-73 (1888).

[11] Sage, B. H., and Lacey, W. N., Ind. Eng. Chem., **40**, 1299-1301 (1948).





Skelly Oil Company's Schafer 1 Gasoline Plant Located near Borger, Texas.

Skelly Revises Schafer Plant For Increased Production

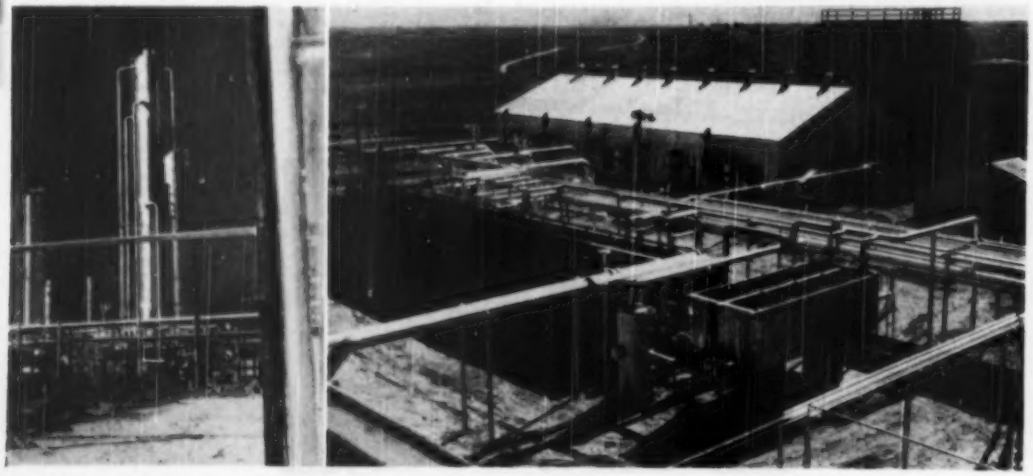
THE Schafer gasoline plant No. 1, near Borger, Texas, of Skelly Oil Company has been revised to increase the volume of production of the various grades of natural gasoline and liquefied petroleum gas. Currently, the plant is processing approximately 11,500,000 gallons daily of natural gas for production of more than 75,000 gallons daily of total liquids.

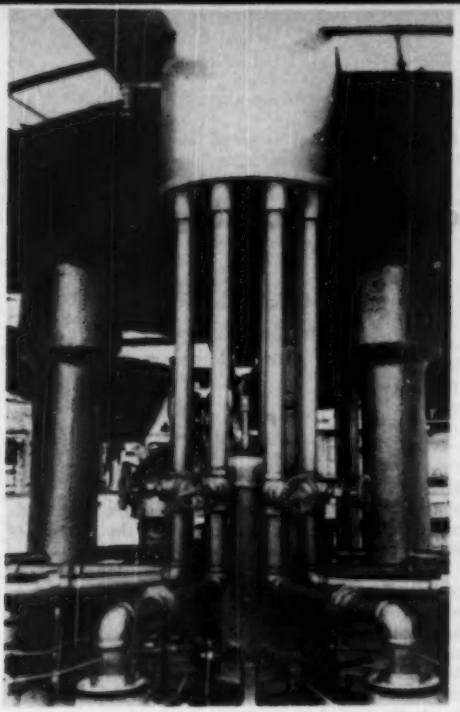
The original Schafer plant, a portion of which is shown in **Figure 1,** was built shortly after Skelly developed extensive oil and gas production in this section of the country, east of Borger. At the time initial construction was contemplated, 20-odd years ago, the equipment selected was considered an advance in gasoline plant design, and operation was comparable with other plants built at that time. However, the need for increased capacity and higher extraction efficiencies led to the revisions and addition of new equipment.

Smooth Change-over

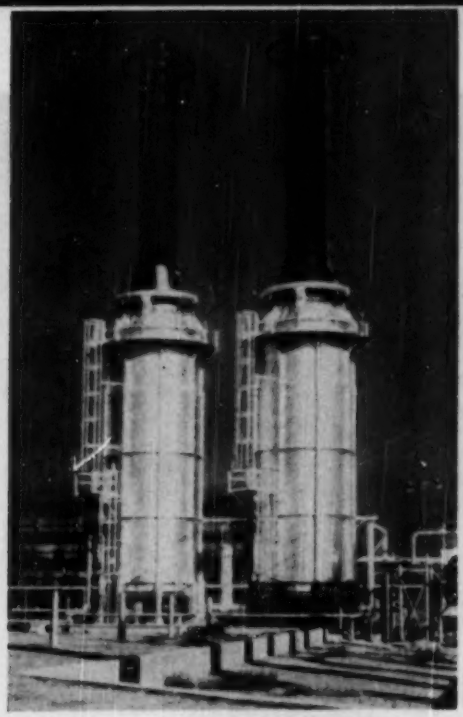
When laying out the plans for rebuilding, installing new columns, pipe lines, engine rooms, and cooling facilities **(Figures 2 and 3)**, one of the objectives was to maintain operation of the original plant as long as possible until the new equipment was ready to be tied in and placed in operation. One of the changes

Left—Distillation Unit with Super-Fractionating Still in Center. Right—Skelly's New Engine Room with Coolers in Foreground.





Pot with Distribution Piping to Burners under Direct-Fired Heater in Skelly's Plant Located in the Texas Panhandle.



Rich Absorption Oil Heater and Heater which Prepared Process Oil for Pumping through Reboilers in Schafer Plant.

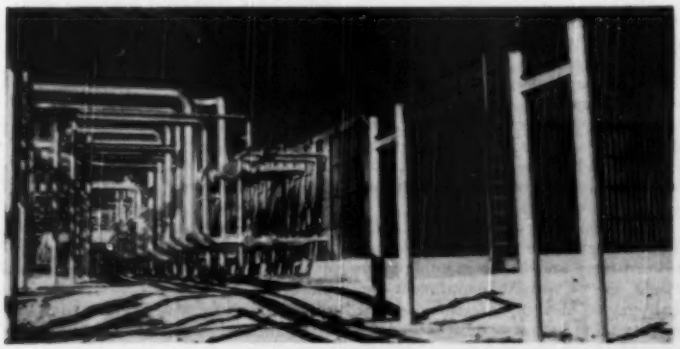
concerned the inlet gas meter runs. New meter runs were installed on the gathering lines and the piping changed on the inlet scrubbers. Previously, the master meters had been installed on meter runs on the field side of scrubbers and separators. As a result, they were subjected to fouling by pipe line scale and condensate. The new system eliminated these difficulties.

Direct-Fired Heaters

Large volumes of saturated and superheated steam were required in the original plant for preheating the rich absorption oil, operation of the distillation equipment and fractionator reboilers. Since the new process required higher temperatures than could be economically obtained with the existing equipment, two large vertical tube, direct-fired heaters **(Figure 4)** were installed. They are used to supply heat for distillation and processing.

The method of firing these furnaces follows accepted practices, but the equipment for distribution of fuel gas is somewhat unusual. As shown in **Figure 5**, fuel gas enters a pot or drum on the concrete floor beneath the heater to permit liquids and scale to drop out before the gas enters the burners. Piping to each burner from the drum is made from a pipe collar welded to the head of the drum. The collars are in a circle near the edge of the drum head. Each burner line is equipped with a valve for regulation of the individual burner, or to permit it to be taken out of service without disturbing the volume controller. A ground union joint in the line simplifies removal of a burner for inspection or repair.

Tower Containing Cooling Equipment over which Cold Water from Spray Tower is Pumped.



Treating of Sour Gas

A substantial portion of the inlet gas to the plant is sour gas, which is treated in a unit using monoethanolamine. Some of the gas enters the plant under field pressures high enough for absorption; however, the greater portion of the gas is received at or near atmospheric pressure and is compressed for absorption.

Water for cooling in the plant is pumped over conventional spray towers, then pumped from the base of the tower to a smaller tower containing distribution headers and the coils. This practice of removing the coil sheds from the base of the cooling tower permits locating the cooling tower on the downwind side of the plant to prevent spray from blowing into the process area. Since the coil shed towers are located in the process area alongside the main pipe runs, **Figure 6**, and in front of the engine room, **Figure 3**, a substantial reduction in piping was realized.

Catalytic Cracking

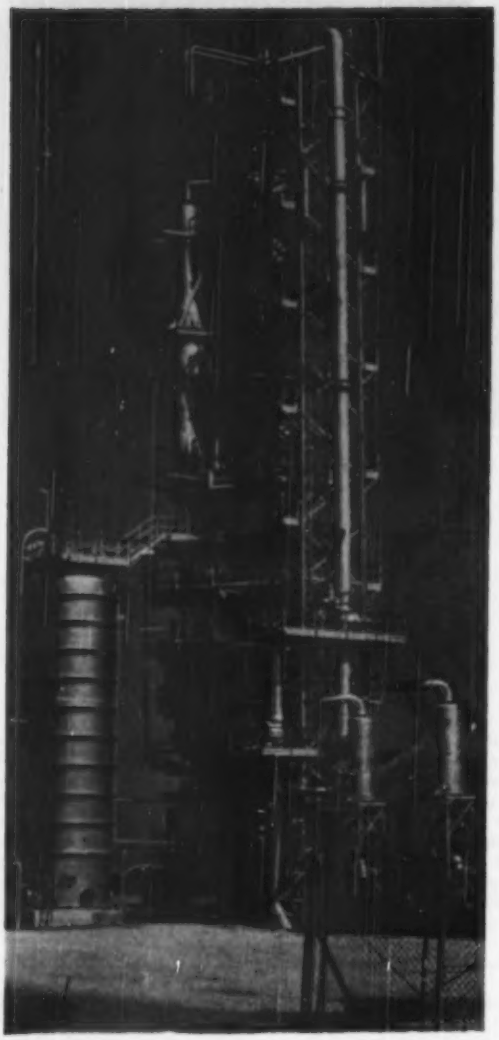
MARSHALL SITTIG
Chemical Engineer
Detroit, Mich.

PART III

THE FLUID Catalytic cracking process—the result of a tremendous development program by Standard Oil Development Company—is the subject of Part III of this series on catalytic cracking.

While the Thermofor catalytic cracking process of Part II and the Fluid process are both moving-bed processes, they differ greatly in catalyst size and catalyst transfer methods. In the Fluid process, the catalyst may average 300-mesh (about 40-micron particles). In the Thermofor process, the catalyst varies from 4-10-mesh in size. The fluid process derives its name from the method by which these particles are transported and contacted with hydrocarbon vapors in the process.

This part of the series describes the history and development of the fluid process to its present status with extensive references to permit detailed study. Also included are discussions on late improvements and some of the more pertinent problems of the process.



UOP Catalytic Cracking Unit at Detroit which uses powder catalyst in a "Fluidized" Operation.

THE principle of the Fluid catalytic cracking process[78] is not new, a patent on the roasting of ores[79] granted in 1879 probably being the forerunner of the present Fluid process. However a thought generally occurs to a number of people before it reaches the mind of the person or group with the genius to appreciate its full implications and to apply it under optimum conditions. Such a group was the Standard Oil Development Company. The original Esso patents were issued to W. W. Odell in 1934 and reissued in 1940.[80] Further patents to the Esso group followed.[81, 82, 83, 84, 85]

Development of the Fluid catalyst process by Standard Oil Development Company covers a ten year period. Years of hard work by hundreds of operators, mechanics, chemists, chemical engineers, mechanical engineers, and analysts had to be coordinated and concentrated to bring the revolutionary technique into actual accomplishment, according to R. P. Russell.[86]

Hydrogenation work in the early 1930's began the catalytic parade toward more and better gasoline from crude oil. Extensive equipment requirements and insufficient gasoline quality from hydrogenation turned the research spotlight on catalytic cracking.

Fixed-bed catalysts attained pilot-plant operation and neared the commercial stage on the drawing boards. Then a powdered-catalyst pilot plant was built in which the powder was forced into a vaporized oil stream by a screw conveyor. The design then approached commercial size plant construction. At this point four hundred individuals (one-third technical men) had worked two years and spent nearly a million dollars on this one process.

Then it became clear that if the proper amount of gas were mixed with the catalyst, it became fluid and could be made heavier or lighter as desired by changing gas addition and by controlling the speed at which the new fluid moved through vessels or pipes. This technique of changing the density of the fluid could be used through a system of standpipes to generate any desired pressure at any particular point in the system and by proper manipulation could bring about recirculation of catalyst through the unit

without the necessity for any moving mechanical parts.

Thus five million man hours of research, development, and engineering went into the final Fluid process. An additional one hundred twenty five thousand hours of engineering work are required to design a specific plant installation.[86]

Further details of the development of the Fluid process with particular reference to pilot-plant development may be found in the literature.[87]

Fundamental Theory of Fluidization

The widespread commercial application of the Fluid catalyst process in the petroleum industry has far outdistanced work on a basic understanding of many of the principles involved in the fluidization of a solid by a gas. Since it is a mechanical phenomenon, subject to empirical interpretation, much can be done without this knowledge. Efficient design work, particularly from the standpoint of producing the most economic design, demands knowledge of the basic principles, however.

Some generalizations regarding the handling of solids-gas reactions are presented by Kelbach.[88] Basic observations from a study of fluidizing processes in laboratory equipment have been published.[89] Pressure drop, heat transfer, and critical sizes of equipment were studied in the latter work. Pressure drop was found to be practically independent of gas velocity and to equal the weight of suspended solids over the area in question. The work on heat transfer indicated little effect of suspended solids on heat transfer rates, but the ranges covered were very narrow and firm conclusions could hardly be drawn. A gap in the published literature definitely exists on the subject of heat transfer to and from fluidized-solid mixtures. A considerable wall or diameter effect on fluid flow was noted in tubes of diameter less than six inches. An equation has been presented for the calculation of the residence time of a particle in a Fluid reactor.[90]

The fundamental laws relating to the fluidization of solid particles have been studied using air and water as the fluidizing media by American[91] and by Russian[92] investigators.

The Original Upflow Process

A Fluid catalytic cracking plant consists essentially of three sections: cracking, regeneration, and fractionation.

Regenerated catalyst from a storage hopper flows by gravity down through a standpipe wherein a pressure head is build up on the catalyst. The latter is picked up by the hot fresh oil vapor and carried into the reactor.

In some early units a furnace was employed to preheat the charge. Just as in the development of Thermofor cracking, however, a technique was developed for the processing of liquid charge stocks. This was accomplished by introducing the hot catalyst directly into cold oil and vaporizing the oil at the solids-pickup point.

Although high catalyst concentrations are obtained in the fluid reactor, the solid-gas mixture is very turbulent through the entire length of the reactor, and resembles a boiling liquid in many respects. The cracked products and spent catalyst (entrained by the rapidly flowing vapors) pass overhead together from the reactor and are separated in dust recovery equipment.

The spent catalyst from the dust recovery equipment drops into a storage hopper, flows down a standpipe, is picked up by an undiluted air stream and is carried to the regenerator in which carbonaceous products are removed by combustion. The regenerator is a large reaction vessel quite similar to the cracking reactor, and flue gas and catalyst pass together from the top of it to further dust recovery equipment. The regenerated catalyst drops into the fresh catalyst storage hopper and completes the cycle.[93]

The cracked products are fractionated in conventional equipment and the flue gas is vented to the atmosphere.

These Fluid plants are characterized by the absence of cycle-timing devices or mechanical catalyst-circulating equipment.

Heat evolved in regeneration is used to:

1) Preheat the gas oil feed.
2) Produce steam.
3) Supply the heat of the cracking reaction.

Reaction temperatures may vary from 800-1000° F. and regeneration temperatures from 1000-1200° F.

The Improved Downflow Process

Continued development work on Fluid catalytic cracking evolved the "downflow" or "boiling-bed" type of reactor wherein only a small portion of the catalyst passes overhead with the oil vapors rather than all of it as in the upflow process just described. The advantages of the newer downflow system are as follows:[93]

1) The problem of dust recovery has been greatly simplified since only about 0.5 percent of the circulating solids stream must be recovered in this manner.

2) The level of solids and thus the contact time in the reactors can be set at will. In upflow operation the solids holdup is a function of numerous operating variables.

3) External catalyst hoppers are not needed because the reactor and regenerator act as storage vessels themselves.

4) The height of the supporting structure is less, due to lower standpipe length because of less pressure drop in the fluidized solid circulating stream.

5) The solids recovery equipment may be incorporated partly within the reaction vessels themselves in the form of internal cyclones.

The passage of gases or vapors upward (counter to gravity) at controlled rates through a mass of powdered solids produces the "fluidized fixed bed."[94] The passage of the gas or vapor causes the powdered solid to become mobile so that it moves about, resembling an agitated liquid. The particle size of the powder is regulated so that little of it is carried out of the reaction zone with the gas or vapor.

The raw oil charge stock, usually gas oil, is preheated by heat exchange with a recirculated oil stream from the fractionating column bottoms as shown in **Figure 7,** see next page.

It may then go to a catalyst-to-oil heat exchanger, where it receives further preheat from a catalyst stream which circulates between the exchanger and the regenerator and which is propelled fluidwise by a fresh air stream. The main purpose of this heat exchanger, whose use has been advocated in Fluid cracking plants designed by Universal Oil Products Company, is to give a wide degree of flexibility to the catalyst-to-oil ratio. As there is a definite amount of heat to be removed from the regenerator, it is obvious that, when part of it is transferred to the heat exchanger, there will be less left to be transferred to the catalyst circulating between the regenerator and the reactor; thus a lower catalyst-oil ratio is permitted.

A regenerated catalyst cooler in which a part of the heat of regeneration is transferred to boiling water is favored in Esso designs.[95] The incorporation of such an exchanger permits reduction in the catalyst-oil ratio below that normally set by a combination of carbon content of spent catalyst and regeneration temperature, just as the catalyst-to-oil exchanger does. These exchangers are used in those cases where excess heat is available in the system. When there is a heat deficiency, it is supplied by heating the charge further in a fired tubular heater.

After preheating, the oil enters the reactor riser where it comes in contact with the hot regenerated catalyst flowing from the regenerator. The oil is

now completely vaporized, and the catalyst is fluidized to a relatively light condition so that the mixture flows upward into the reactor. Usually recirculated process gas or steam is injected into the reactor riser to aid in fluidizing the mixture.

The velocity in the reactor is greatly decreased from that in the riser as a consequence of the greater cross-section of the reactor so that the solids now tend to concentrate in the gas stream. Under these conditions the solids form a dense, turbulent bed having a relatively clearly defined level. The velocity in the vessel is sufficiently low and enough disengaging space is provided above the level so that only a small amount of solids passes overhead with the gas. The reaction vessel is made large enough to afford the required reaction time in the dense bed of fluidized solids, and the major portion of the solids fed to the reactor is withdrawn through a well to the outlet solids standpipe.

The vapors leaving the reactor do, however, carry some of the catalyst fines with them. The major portion of these catalyst fines is recovered by passing the vapors through cyclone separators. The remainder of these fines is recovered as a slurry at the bottom of the primary fractionating column. The bottom of this fractionating column is of special design. Instead of the conventional bubble plates, it simply contains a series of baffles which are less prone to plugging, over which the bottom product is circulated by a slurry pump through a waste-heat boiler and then back to the column above the feed point which is at the bottom of the column. This circulating stream both recovers heat from the hot column feed and scrubs out any catalyst entrained in the feed.

A small portion of this circulating slurry stream is constantly withdrawn for recovery of the catalyst content.[93] This may amount to 3-10 percent of the fresh reactor charge and contains about 0.5 pound of catalyst per gallon. Early practice was to send this slurry return stream directly to the reactor but high carbon formation resulting from the introduction of so much heavy stock proved undesirable. Hence slurry return is now treated in a Dorr thickener where about 70 percent of the heavy oil is removed as a clear oil containing less than 0.01 pound catalyst per gallon. The thickened sludge is diluted with fresh feed and sent to the reactor along with the main feed stream.

Regeneration air enters at the base of the regenerator riser and carries the catalyst from the reactor outlet solids standpipe upwards into the regenerator. As the regenerator is quite large, some being more than 40 feet in diameter, a perforated plate is installed to assure even distribution.

Regenerated catalyst flows into the drawoff wells, down to the fresh catalyst standpipes and also down to the catalyst heat exchanger. The material in the standpipes is quite dense so that the head developed is sufficient to cause catalyst to flow into the reactor and into the heat exchanger, the flow rates being controlled by slide valves. The products of combustion leave the regenerator through a cyclone separator which removes the greater part of the entrained catalyst. The gases then go through a steam generator, which recovers a large part of the waste heat, and then through a Cottrell electrical precipitator, which recovers most of the remaining catalyst. From there the gases are discharged to the atmosphere.

Improvements in Fluid Units

Just as in the development of the Thermofor process, there was a trend from the use of more or less irregularly shaped catalyst particles to spherical particles having much lower attrition loss, there has been a trend from the early ground catalysts to specially manufactured micro-spheroidal catalysts of narrower size range.

One of the latest Fluid units which utilizes this new catalyst together with other design improvements is that of Shell Oil Company at Deer Park, near Houston.[95, 96, 97] A description of this unit should serve to illustrate the latest developments in the application of the art of Fluid cracking.

One of the features of this unit is the fact that the regenerator vents directly to the atmosphere. This eliminates the waste heat boiler, the Cottrell precipitator, and the attendant ductwork. This has been made possible through incorporation of two-stage cyclones within the reactor in place of single-stage cyclones previously used.

A smaller line with no complicated expansion bends is used between the reactor and the fractionating column. This was made possible by the utilization of the maximum possible pressure drop in this section.

Two-stage cyclones are also used in the top of the reactor. The lessened catalyst recovery problem resulting from this change permits the elimination of the Dorr slurry thickener in favor of a simple settling tank.

Withdrawal of catalyst from the reactor through a special stripper rather than simply through a side well as in earlier units has been adopted in this unit. An "egg-crate" section is utilized[96] with each cell having its own stripping-steam connection, reducing oil loss at this point to a minimum. The stripper has 26 box-sections, each 23 inches square and 15 feet high[97] with five steam nozzles in each compartment.

Distributor grids of new design have been incorporated in the base of both reactor and regenerator. They are composed of hollow, parallel beams which are shaped to minimize erosion and whose faces are fitted with renewable wear plates.

A pre-heating furnace enables the reduction of the catalyst-to-oil ratio to 7:1. A feature of this furnace is the incorporation of superheating tubes for the wet steam generated in the catalyst exchangers and in the slurry oil waste-heat boiler.[97] Here are the advantages gained from the low catalyst-to-oil ratio:

1) Smaller risers and standpipes may be used.
2) Erosion rate is reduced.
3) Steam stripping efficiency is increased, reducing the amount of steam required. Oil stripping in this unit requires only 10,000 pounds per hour of steam at 550° F. and 225 psi. when circulating catalyst at a rate of 13 tons per minute. This is less than half the steam consumption in earlier units where catalyst rates were upward of 30 tons per minute.
4) The quantity of regeneration air required is reduced.

Over-all height of the unit is lowered. The top of the regenerator cone is but 140 feet above grade[97] which may be compared with 175 feet in earlier units.[98] This was made possible by accurate knowledge of pressure drops from operation of previous units resulting in closer design in this case.

Miscellaneous minor improvements were also made in the design of the unit at Deer Park for ease of operation and maintenance. These include ample room between pieces of equipment, accessible piping, manholes in equipment, and many hoists and cranes to permit removal and handling of heavy parts, and plenty of catwalks for easy access and repair.

Fluid Cracking for the Small Refiner

Universal Oil Products Company has pioneered work on a unique variation of the usual equipment placement in Fluid units which is particularly adapted to small units.[11, 99] It consists of placement of the reactor directly on top of the regenerator in a single self-supporting shell, eliminating the heavy support structure necessary for the support of separate units at considerable elevation above grade.

The first small Fluid units constructed did not employ this advanced design but did embody some very interesting design innovations. Such a unit was the 2600-barrel-per-day unit

constructed at the plant of Frontier Refining Company, Cheyenne, Wyo.[100]

One novel feature of this earlier plant was the operation of the regenerator under pressure, eliminating the necessity for a long dropleg under the regenerator and reducing the over-all height of the unit from 240 to 130 feet. A second novel feature was the use of a catalyst scrubber whereby regenerator effluent gas was contacted countercurrently with the feed, preheating the feed by direct heat exchange and simultaneously recovering catalyst entrained overhead from the regenerator.

The use of microspheroidal catalyst in the newer all-in-one units has eliminated the need for the oil scrubber or any other secondary catalyst recovery. A second advantage over the earlier design incorporated in the Frontier unit is the fact that the new unit permits countercurrent operation in the regenerator. Since the reactor is above the regenerator, catalyst is passed through the regenerator countercurrent to fresh air entering at the bottom. This has permitted reduction in the oxygen content of the flue gas to 0.5-1.0 percent from two or three times that amount in earlier units employing the conventional boiling bed.[99]

The over-all height of these new units is about 125 feet.

Operating cost for the small-scale process for a 2000-barrel-per-day unit operating at 60 percent conversion on gas oil feed are estimated at about 29 cents per barrel per day of charge, taking credit for steam production but no credit for fuel-gas production.[99]

The first commercial unit patterned upon the improved all-in-one design was put on stream at the Detroit refinery of Aurora Gasoline Company on June 10, 1947.[101, 102] It was designed for 3300 barrels per day charge at 60 percent conversion or 4030 barrels per day charge at 50 percent conversion. Elimination of the air riser into the regenerator has eliminated the use of costly expansion joints in this line, a feature of large Fluid units. Also the air preheater is directly connected to the regenerator in this unit, eliminating the hot-air line and any expansion joints therein.

Carbon Formation and Carbon-Burning

During the recent war, it was obviously critical to push Fluid cracking units to their peak capacity. It was found that carbon-burning capacities of these plants were the bottlenecks [103] and equipment modifications were made with this in mind.

This was done in two ways: a) by improving the percentage of the feed converted to carbon on the catalyst and b) by altering regeneration capacity so that a greater carbon-burning rate was possible. Improvement of the conversion to carbon was achieved partially through improved stripping of entrained hydrocarbon vapors from the catalyst leaving the reactor, and partially by a reduction in the catalyst-to-oil ratio, permitting increased regenerator temperatures.

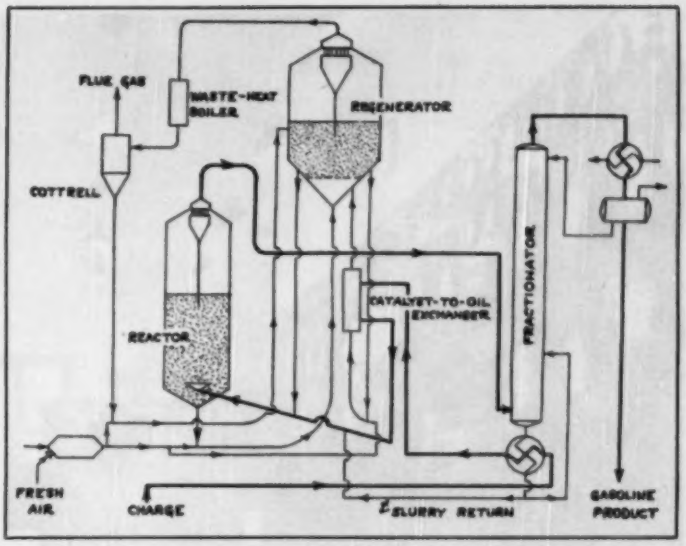


FIGURE 7

This increase in permissible regenerator temperature also gives increased burning rate, which for a given contact time in the regenerator, permits more efficient utilization of combustion air. Oxygen concentrations in flue gas have been lowered from 2-3 percent to half that amount, resulting in higher carbon-burning capacity. These figures are based on an example wherein regeneration temperature was raised 100° F., from 1050° to 1150° F., by decreasing catalyst-to-oil ratio from 23:1 to 10:1 at constant reactor temperature and conversion.

The most important item in alteration of regenerator capacity consisted of operating the regenerator under pressure at 5 psi. This effected a total gain in carbon-burning capacity of 30 percent. This is estimated on the basis of no change in the carbon-hydrogen ratio of the coke carried to the regenerator. Improved stripping increases this ratio so that an additional 15-20 percent gain in capacity is possible due to the fact that less oxygen is used in the combustion of hydrogen when burning carbon-rich coke.

Typical values for carbonaceous content of spent fluid cracking catalyst run from 1-2 percent.[104] It is interesting to compare these figures with those for the Thermofor process [73] of 6-8 percent and for the Houdry process of about 1 percent.[39]

The operating variables in a fluid catalyst regenerator may be classified under headings [104] as follow:

1) Temperature of regeneration. Increase in temperature increases the reaction rate of carbon burning. On the other hand, catalyst sintering involving permanent loss of activity, and materials of construction problems set an upper temperature limit of 1100° F. for synthetic catalyst. This upper limit is 1050° F. for clay catalyst[105] is set by the deactivation effects of temperature and steam and the necessity for reasonable catalyst makeup rates.

2) Type of catalyst. The problem of temperature deactivation of catalyst has already been mentioned. In addition, the cracking catalysts exert a directive effect on the combustion reaction in the regenerator and various catalysts will produce various CO_2:CO ratios. These ratios are fixed by temperature, particle size, and catalyst composition.[106] The largest amount of CO is obtained at about 1200° F. Ratios of CO_2:CO run from 0.8-1.0 for synthetic catalyst and from 1.5-1.7 on natural catalyst. A decrease in this ratio from 1.9 to 1.0 gives a 6 percent increase in coke capacity due to lessened heat release.

3) Analysis of catalyst deposit. The carbon content may run from 93 percent to 87 percent and hydrogen content from 7-13 percent depending on stripping efficiency of the spent-catalyst stripper. Poor stripping results in hydrogen-rich coke, requiring increased combustion air.

4) Fraction of coke removed during regeneration. Of the 1-2 percent coke on the spent catalyst, 0.3-1.0 percent

Operating Control Room of a Downflow Fluid Catalytic Cracking Unit.

remains after regeneration. The difficulty of complete burning must be balanced against activity in the reactor and the fact that heavily coked feed to the regenerator is more prone to entrainment from the regenerator.

5) Residence time in the regenerator. With good air distribution, a residence time of five minutes should suffice to reduce carbon content to 0.5 weight percent. Actually at prevailing bed depths and gas velocities, times actually used are of the order of 10-20 minutes. This time should be held down, however, because loss of activity and increased makeup rate result from prolonged contact at regenerator temperatures.

6) Regeneration pressure. Pressure operation definitely aids regeneration and must simply be balanced against cost of air compression.

The formation of carbon on catalysts in both fluid and fixed-bed processes has been studied in detail by Voorhies.[106] Equations and graphical correlations have been developed in this work which permit prediction of carbon formation from a knowledge of conversion, feed rate and reactor residence time.

Mechanical Features of Fluid Plants

The use of flow lines from three to six feet in diameter, which preclude use of expansion bends has resulted in the development of special expansion joints for Fluid cracking plants.[107, 108, 109]

One section of pipe in the Esso plant Baltimore is nine feet in diameter. Arrangements must be made to permit expansion of over 14 inches in length between room and operating temperatures.[86]

An expansion joint employed in one fluid plant is 72 inches in diameter. Catalyst suspension at 25 psi. and 1070° F. passes through the joint which has a lateral design movement of 2.9 inches and a linear movement of 1.6 inches. Two small pipes encircle the joint and supply inert gas to the bellows at higher pressure than the catalyst stream, thus preventing accumulation of catalyst dust in the bellows elements and insuring proper joint movement.

A specially welded stainless steel bellows is employed as the basis of these huge expansion joints.

The question of erosion would seem of tremendous importance when one first considers the fluid catalyst process. Actually, plain carbon steel equipment is largely used and erosion is controlled and minimized [92] by:

1) Proper choice of velocities.
2) Streamlining.
3) The use of protective wear plates.

Virtually every shutdown which delayed gasoline production during World War II was due to erosion in one form or another.[110] Ceramic lining of dense-phase catalyst lines has been abandoned in favor of carefully curved lines of steel or alloy depending on the temperature encountered. It is interesting to note in this regard that plain carbon steel is superior to alloy steel on an erosion basis alone.

A change in the type of cyclones used, a lowering of permissible velocities in cyclones and reduction of solids loading in cyclone feeds have contributed to increased cyclone life.

Erosion of slide valves controlling the main process streams was a serious problem in early fluid plants. This problem was met by designing for throttling operation at a more nearly wide-open position and by the use of two valves in series, one always wide open so that a substitute was always available in case of emergency.

Refractory linings for vessels and pipelines in fluid units and their evolution have been discussed in a recent publication.[69A]

The problem of conveying the catalyst dust from freight cars to storages and thence to the process equipment as well as between storage points within the unit is unique to the fluid process. The Fuller-Kinyon conveying system has long been used in the pneumatic conveying of various solids and proved applicable to the conveying of catalyst. The Fuller-Kinyon pump [111] has been described in a series of patents issued to Alonzo C. Kinyon, James W. Fuller, and their colleagues beginning in 1918. The pump consists of a screw conveyor of gradually decreasing pitch which compresses particulate solid material at the same

time it advances in the direction of the entrance to a pipe system. Thus the backward leakage of gas into the solids feed line is prevented.

Control Instrumentation

Instrumentation of course plays an important part in fluid catalytic cracking.[99,104,112,113,114]

Oil flow to the plant is controlled at a constant rate.

Oil feed temperature to the unit is controlled by regulating the flow of fuel to the preheating furnace.

The reactor temperature is controlled by adjusting the amount of hot fresh catalyst entering the reactor.[113] The catalyst flow is regulated by a slide valve at the bottom of the regenerated catalyst leg. These slide valves are quite unusual. They may range in diameter from 34 to 42 inches and weigh approximately nine tons each. Their cost is about $10,000 each.[113] This control essentially governs conversion since catalyst level and reactor temperature are the two factors involved in variation of conversion. Independent variation of catalyst-to-oil ratio by making adjustments through the entire plant is used to set the desired conversion.

The reactor operating pressure is controlled by a pressure controller at the suction of the compressors taking overhead gas from the fractionating column.

The height of the boiling bed as indicated by the pressure drop across the bed controls the slide valve in the line out of the reactor to the spent catalyst stripper. In order to measure pressures in a conduit filled with a gas-solids mixture, special precautions must be taken to prevent plugging the small instrument lines with the fine catalyst dust. This is done by constantly sweeping through the lines into the process equipment with a small flow of purge gas which may be hydrocarbon gas or inert gas. The flow in these lines is so small that any effect of the purge gas on true static pressure reading at a given point is negligible.

The pressure drop over the spent catalyst stripper controls the slide valve in the line out the stripper into the regeneration air line.

Recycle Catalyst Cooler

The recycle catalyst cooler, whose function processwise has already been described, is dually controlled. Two slide valves function in series, one being controlled by the temperature in the regenerator. In the event that this first control demands too high a flow through this exchanger, the second valve which is controlled by the pressure drop across the cooler, goes into action to prevent plugging. Thus the combination may not be able to handle extreme temperature rise in the regenerator. Under some conditions CO formed in combustion of the coke deposit may burn to CO_2 in the top of the regenerator above the catalyst level. This can result in very high temperature at this point so emergency water sprays are incorporated to permit the operator to assume temporary control prior to returning the regenerator to normal operation.[104]

Regeneration air pressure is controlled at constant pressure at the compressor discharge.

Air to the spent catalyst standpipe pickup point is regulated to give suitable flow characteristics and also to hold down burning rate in the carrier line. Added air is used to move the catalyst in the recycle cooler system and still more air may be added directly to the bed through auxiliary air lines.[104]

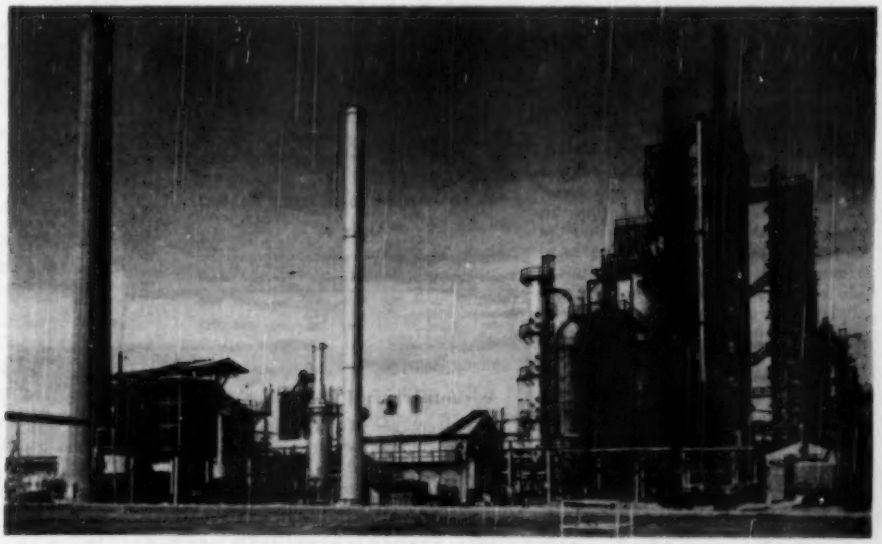
A recorder shows the oxygen content of the flue gas leaving the regenerator. Operating conditions are set to hold this to a minimum.

Regenerator pressure is held constant by a damper in the flue gas line out of the regenerator. This may be controlled by the pressure difference between the reactor and the regenerator.[99]

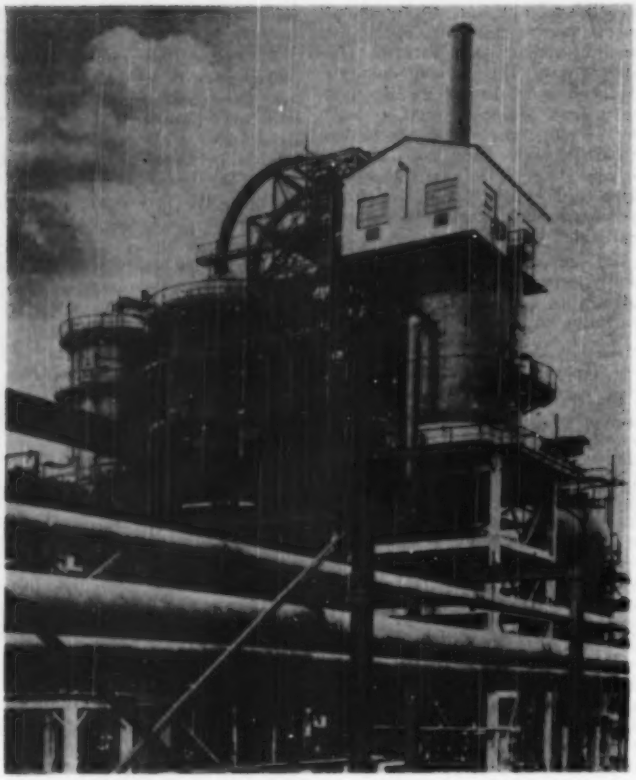
Slurry withdrawal from the fractionator bottom is controlled at constant rate by a flow controller, controlling the steam to the pump to avoid the use of an automatic valve in such erosive service.[113] Flushing oil is bled into the orifice taps at this point in much the same manner that purge gas was used to clear the pressure points in gas-solid conduits.

Of course the brief description of fluid cracking unit instrumentation here applies to the catalyst system alone. Conventional control setups are employed on the auxiliary refinery operations of fractionation, etc.

Detailed sketches of instrument application to the preheating furnace, the reactor, the regenerator, and the



Fluid Catalytic Cracker. This one is located in Billings, Mont.



Closeup of Fluid Cat Cracker Recently Put Into Operation at Cincinnati, Ohio.

fractionator are available in one manufacturer's bulletin.[114]

Turnarounds and Maintenance

The investment cost of fluid cracking plants compares favorably with the cost of installing new thermal cracking facilities as the result of careful engineering work.[110] In order to make a wholly attractive picture to the prospective investor however, maintenance cost must be held down and the percentage of total time on stream kept high. This means that the major periodic cleanouts or "turnarounds" must be kept short as possible and the day-by-day upkeep and replacement of minor parts not necessitating shutdowns must be held to a minimum.

A thorough picture-story of modern turnaround technique as practiced at the Gulf refinery in Philadelphia has been presented.[115, 116]

The turnaround procedure employed by The Texas Company on their fluid units has also been described.[117]

Maintenance costs are stated to be less than those encountered in thermal cracking.[92] Maintenance costs including minor revisions to equipment have been found to be 5-6 percent per year of the capital investment. Repairs due to erosion in early units cost from 0.8-1.7 percent of the capital investment.

Recent developments, particularly the use of microspheroidal catalyst, have resulted in reduced maintenance costs.[11]

These costs are summarized Table 2.

TABLE 2

Type of Catalyst	Microspheroidal			Powdered Natural		
Charge, Bbl./Day	900	2700	4500	900	2700	4500
Maintenance Labor & Mat'l.—$/Bbl.	.073	.049	.040	.081	.054	.039

Advantages and Disadvantages

Disadvantages of the fluid-type reactor[111] include the fact that the system is not adapted to countercurrent operation. Also, due to the turbulence of the fluid bed, contact time must be treated statistically with respect to the contact time of the individual particles. Holdup of solids must then be sufficient so that, on the average, the desired contact time is attained and only a permissible portion of the solids is allowed to escape from the reactor before a certain critical contact time.

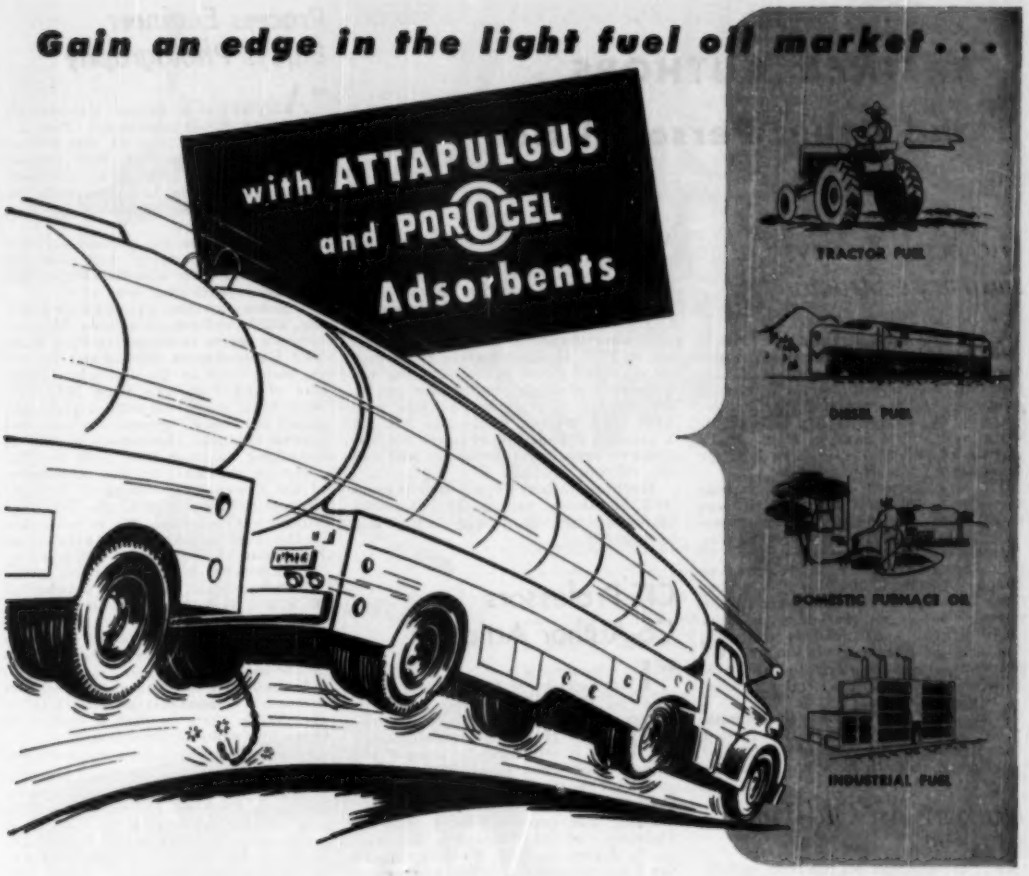
On the other hand, the complete and efficient contact obtained between gas and solid, the mechanical simplicity of the equipment, and the uniform conditions existing throughout the reactor as a result of the excellent mixing, are compelling advantages.[111]

BIBLIOGRAPHY (Cont'd)

[75] Daniels, L. S., Petroleum Refiner, 25, (9), 435 (1946).
[76] U. S. 212,508 of 2/18/1879 to C. E. Robinson.
[77] U. S. 1,984,380 of 12/18/34 and Reissue 21,526 of 8/6/40 to W. W. Odell.
[78] U. S. 2,303,047 of 11/24/42 to C. E. Hemminger.
[79] U. S. 2,303,680 of 12/1/42 to F. G. Brueckmann.
[80] U. S. 2,320,273 of 5/25/43 to E. J. Gohr, W. I. Thompson, & H. Z. Martin.
[81] U. S. 2,322,019 of 6/15/43 to C. E. Hemminger.
[82] U. S. 2,322,075 of 6/15/43 to C. W. Tyson.
[83] Russell, R. P., Petroleum Refiner, 23, (1), 9 (1944).
[87] Carlsmith, L. E., & Johnson, F. B., Ind. Eng. Chem., 37, 451 (1945).
[88] Kalbach, J. C., Chemical Engineering, 54, 136 (1947).
[89] Parent, J. D., Yagol, N., & Steiner, C. S., Chem. Eng. Progress, 43, (8), 429 (1947).
[90] Wilhelm, R. H., & Kwank, M., Paper presented at A.I.Ch.E. meeting, St. Louis, Mo., May 13, 1947.
[91] Obryadchikov, S. N., & Marushkin, B. K., Neftyanoe Khozyaistvo, 24, (11), 35 (1946).
[92] Murphree, E. V., Fischer, H. G. M., Gohr, E. J., Sweeney, W. J., & Brown, C. L., Refiner, 22, (11), 357 (1943).
[93] Murphree, E. V., Fischer, H. G. M., Gohr, E. J., Sweeney, W. J., and Brown, C. L., Refiner 22, (11) 357 (1943).
[94] Thomas, C. L., & Hoekstra, J., Paper presented before Petr. Div. of Am. Chem. Soc., Sept., 1944.
[95] Armstrong, R. T., & Denker, B. L., Heat Engineering, 22, (4), 50 (1947).
[96] Daniels, L. S., Petroleum Refiner, 26, (2), 85 (1947).
[97] Thornton, D. P., Jr., Petroleum Processing, 2, (3) 173 (1947).
[98] Wickham, H. P., Petroleum Refiner, 24, (7), 263 (1945).
[99] Read, D., Petroleum Refiner, 25, (5), 223 (1946).
[100] Newman, W. R., Nat. Petroleum News, 37, (6), R-82 (1945).
[101] Anon., Petroleum Refiner, 26, (9), 704 (1947).
[102] Bland, W. F., Petroleum Processing, 2, (9), 670 (1947).
[103] Murphree, E. V., Gohr, E. J., Martin, H. Z., Ogorzaly, H. J., & Tyson, C. W., Petroleum Refiner, 24, (11), 423 (1945).
[104] Scuggs, J. F., Petroleum Refiner, 26, (3), 129 (1947).
[105] Bergman, D. J., & Bertetti, J. W., Petroleum Processing, 2, (6), 425 (1947).
[106] Voorhies, A., Jr. Nat. Petroleum News, 37, (36), R-697 (1945).
[107] Anon., Heat Engineering, May-June, 1944, 58.
[108] Anon., Heat Engineering, Aug.-Sept., 1944, 107.
[109] Anon., Heat Engineering, Jan., 1947, 12.
[110] Fleck, B. J., Oil & Gas Journal, 45, (22), 72 (1946).
[111] Kalbach, J. C., Chem. & Met. Eng., 51, (6), 94 (1944).
[112] Mattix, E. D., & Groendyke, R. W., Oil & Gas Journal, 43, (9), 105 (1944).
[113] MacDonald, M., Petroleum Refiner, 25, (10), 471 (1946).
[114] Considine, D. M., & Jones, R. E., Bulletin No. Oil-M-2, Brown Instrument Co. (1946).
[115] Anon., Petroleum Processing, 2, (8), 569 (1947).
[116] Anon., The Kelloggram, No. 5, The Kellogg Company (1947).
[117] Anon., Oil & Gas Journal, 44, (47), 239 (1946).

End of Part III. Part IV, the last will appear in an early issue.

Gain an edge in the light fuel oil market . . .



In a highly competitive market for distillate fuel oils—Diesel, domestic furnace, tractor, industrial—the refiner who places emphasis on high quality in his products has a decided edge. In fact, selling strategy often is based on points of superiority that assume smaller stature at other times. This applies to other products too—absorption, enrichment, smudge, and insecticide spray oils.

A final straining step using Attapulgus Fullers Earth or Porocel Activated Bauxite is an economically attractive form of light fuel oil quality insurance. These adsorbents are recognized standards for the selective "polishing" of light distillates at low cost. Oils in this range can be filtered to high yields for removal of moisture and sediment. Removal of residual amounts of treating chemicals is accomplished. Moisture haze is removed; color improved or stabilized.

Attapulgus and Porocel adsorbents couple low price with long service life—an unbeatable combination when finishing distillates whose market price generally dictates a minimum of refining expense. Process equipment required is relatively simple and inexpensive—often built from on-site components.

Let's explore the possibilities of improving your position—hence profits—in the light fuel oil market. Our staff is at your service to help select the right adsorbent and the right conditions.

ATTAPULGUS CLAY COMPANY *Fullers Earth* · **POROCEL** CORPORATION *Activated Bauxites*

Dept. W, 210 West Washington Square, Philadelphia 5, Pa.

REFINER AUTHORS and Other Personalities

Nickerson Surveys Oil Industry's Structure

A. L. NICKERSON, whose article "No Time Now for Political Manipulations and Socialistic Experiments" appears on page 63, is director in charge of domestic marketing for Socony-Vacuum Oil Company, Inc. He began work with the company as a service station salesman in 1933, shortly after graduation from Harvard.

He was promoted through various sales positions until in 1941 he was made New England division manager. After a leave to serve with the War Manpower Commission as director of the Placement Bureau, he returned to Socony-Vacuum in 1943. In 1944, he became assistant general manager of the company's Eastern marketing division.

He left this post in 1944 to go to England as chairman of Vacuum Oil Company, Ltd., returning to the U. S. in November, 1946, to become director of Socony-Vacuum.

Nickerson, who was born in Dedham, Mass., lives with his wife, the former Elizabeth Perkins, and their four children in Rye, N. Y.

Harbert An Old-Timer

W. D. HARBERT, whose article, "The Distillation Column Balance—Overhead-Bottoms Split vs. the Feed Composition," begins on page 117, has had several articles published in the PETROLEUM REFINER. Among them were "Distribution Curves" (October, 1948) and "Economic Distillation Design" (April, 1949.)

Harbert, now with Arthur G. McKee & Company, engineers and contractors of Cleveland, was formerly in the research and development division of Consolidated Coal Company, Library, Pa.

After graduating from the University of Oklahoma and receiving his master of science degree in chemical engineering in 1939, Harbert worked for a year on the Gulf Coast before entering the University of Michigan for post graduate courses. For a time he was with Lion Oil Company, El Dorado, Ark., as a process and design engineer for the research department, butadiene unit and the refining division.

Much of Harbert's spare time in spent with his family and in the enjoyment of his hobbies—gardening, fishing and photography.

CIT Professors Co-Author Article

"THE Fugacity of Propene and 1-Butene" by California Institute of Technology faculty members William N. Lacey and B. H. Sage, appears on page 123. Lacey is professor of chemical engineering and dean of graduate studies, and Sage is professor of chemical engineering.

Lacey was graduated from Stanford University in 1911, receiving his engineer's degree in 1912. Transferring to the University of California, he received his M.S. degree in 1913 and his Ph.D. in 1915. After some industrial experience he joined the faculty of CIT. In 1946 he received the Hanlon Award of the Natural Gasoline Association of America and in 1947, the Lucas Medal of the AIME.

Sage, who received his B.S. degree in chemical engineering from the New Mexico College of Agricultural and Mechanical Arts in 1929, took his master's degree in chemical engineering in 1931 and his doctor's degree in mechanical engineering in 1934, both from CIT. He has been associated with Lacey in connection with Project 37 of the API for the past 20 years and has been engaged in investigations of the volumetric and phase behavior of the lighter hydrocarbons during the greater part of this period.

Sage recently was granted the Precision Scientific Award in petroleum chemistry offered through the American Chemical Society. During and sub-

Process Engineer Enjoys Photography

"A SYSTEM of Process Calculations for Light Hydrocarbons, Part I," which appears on page 83, was written by A. J. L. Hutchinson, chief process engineer of Fish Engineering Corporation, Houston. He has been with the company since its formation in May, 1946.

Prior to that he was process engineer for Fluor Corporation, Ltd., for ten years, working in Kansas City, Houston and Los Angeles.

Hutchinson, who was born in Lindsay, Calif., and reared in Palo Alto, received a degree in chemistry from Stanford University in 1919. Later he did graduate work at the California Institute of Technology from 1923-1924. After being connected with several companies as chemist, research engineer and process engineer, Hutchinson worked as consulting engineer from 1930 to 1936.

During the war, he was a member of the Tower Study Group of Primary Process Subcommittee to the Technical Advisory Committee. He is co-author of the TAC report, "Miscellaneous Fractionating Techniques," published by the PETROLEUM REFINER in April, 1947.

Hutchinson is an active member of ACS and is a registered professional engineer in Texas. He is a charter member of the California Natural Gasoline Association and delivered the first paper before the group.

He recently has been in Honolulu where his company is building a refinery. While there he had a chance to enjoy his hobby of photography.

A. L. NICKERSON | B. H. SAGE | WILLIAM LACEY | A. J. L. HUTCHINSON

SUSPENSION TYPE CLEANER for small tubes. Electric motor driven. A long shaft armed with cutter or brush, enters the tube, the motor being supported from above by tackle.

The Direct-drive air or steam-cleaner, long the standard for small tubes such as those in condensers and other heat exchange apparatus.

■ Any tube that's cleanable can be cleaned by one of the many cleaners in the Lagonda line-up. Diameters as large as 18-inch—as small as .495-inch. Straight, curved or bent as sharply as a superheater tube of return bend type. In the half century of Lagonda experience, probably every possible tube cleaning condition has been met. If it's tube cleaning, it's Lagonda. Bring us your problem.

IF IT'S TUBE CLEANING IT'S Lagonda

New bulletin Y-29 gives the full story On request.

Y-290

ELLIOTT Company

LAGONDA DIVISION • SPRINGFIELD, OHIO

Plants at: JEANNETTE, PA. RIDGWAY, PA. • AMPERE, N. J. SPRINGFIELD, O. • NEWARK, N. J. DISTRICT OFFICES IN PRINCIPAL CITIES

MARSHALL F. ALLEN | J. W. DONNELL | KENNETH TURBIN | W. E. MORRIS

sequent to World War II, he has been associated with the Naval Ordnance Test Station. In 1948 he was awarded the Medal of Merit for contributions to the field of rocket propellants during World War II.

Morris Is Leader of Antiknock Studies

W. E. MORRIS, whose article "Influence of Exhaust Back Pressure on Anti-Knock Performance of Aviation Fuels" appears on page 92, is group leader in charge of antiknock studies with E. I. Du Pont de Nemours Petroleum Laboratories in Pennsgrove, N. J. He joined Du Pont last March.

A native of Versailles, Mo., Morris received a degree in chemical engineering from the University of Missouri in 1943. He joined Standard Oil Development Company at Linder, N. J., and there devoted a major portion of his time to aviation fuel quality studies.

His hobbies include golf, softball, and camping.

Donnell and Turbin Contribute Article

J. W. DONNELL, professor of chemical engineering at Michigan State College, and Kenneth Turbin, graduate assistant in that department, collaborated on the article "Calculation Equations for Vapor-Liquid Equilibrium in Multicomponent Mixtures by Punch Card System," page 109.

Donnell, born in St. Jo, Texas, had his undergraduate work in chemical engineering at the University of Oklahoma and his graduate work at Oklahoma University and MIT. His determination to gain wide industrial experience led him to such positions as process engineer for Du Pont Company, petroleum technologist for Continental Oil Company, chemist for Tennessee Copper Company, assistant to the vice president of Lion Oil Company, technical consultant to the office of the Petroleum Administrator for War, vice president of Industrial Lining Engineers, Pittsburgh (a plastic company designing anti-corrosion vessels), a company he and a classmate helped to form.

In addition to his professorship, Donnell maintains an office as consulting engineer in East Lansing, Mich. He is a member of Alpha Chi Sigma, Tau Beta Pi, ACS, AIChE, and SAE, and is a registered professional engineer.

Turbin, who was born in Michigan, enrolled at Michigan State College after three years' service in the Army and was graduated this year with high honors, receiving his degree in chemical engineering. While employed as a graduate assistant, he is working toward his master's degree. When he receives it, he hopes to work in the field of process development. He is a membr of Tau Beta Pi and Phi Kappa Phi.

Married and the father of three children, Turbin spends much of his spare time with his family. Tennis and music are his main recreational interests.

Association Manager Is Speaker and Writer

MARSHALL F. Allen, whose article "Removable Insulation for Refinery Vessels" starts on page 112, has been engaged in trade association and government work in Washington since 1940. In 1949 he was appointed manager of The Magnesia Insulation Manufacturers Association, comprising the major producers of 85 percent magnesia insulation in the country. In addition to his managerial duties for the association, Allen is engaged in a series of studies on the standardization of insulation specifications and is active both as a speaker and a writer on various aspects of industrial insulation problems. He lives in Arlington, Va.

Allen attended William and Mary College, receiving his engineering degree from Johns Hopkins University. During the war, he was associated with the British and Australian governments here and also served with the U. S. Army Air Forces. He was formerly executive secretary of National Aircrafts Standards Association, a subsidiary of Aircraft Industries Association.

Australian Has "Pigeon Pair"

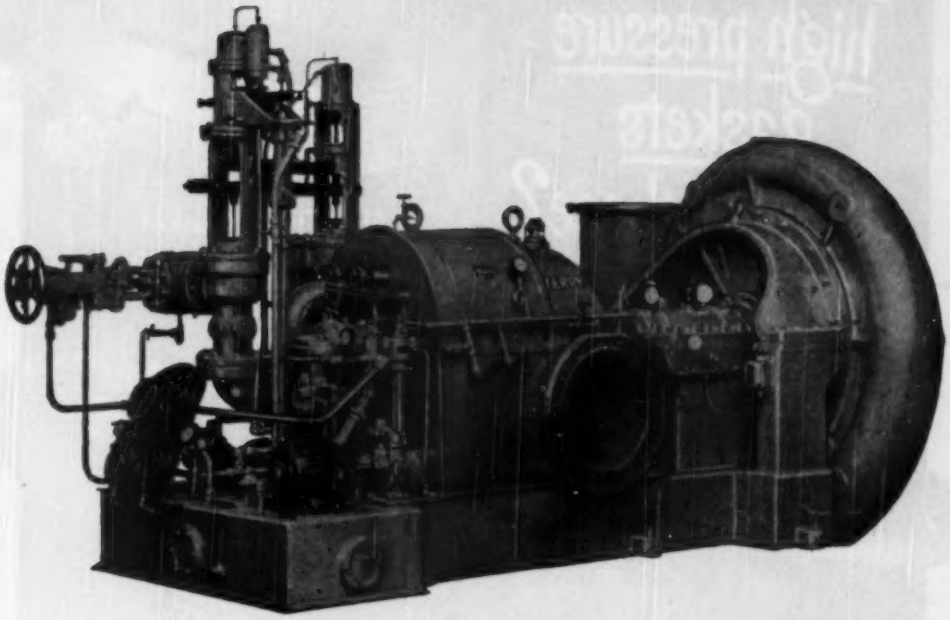
THE "land down under" is no longer thought of as the "land of drought" by Australian George Mapstone whose article "The Chemistry of the Acid Treatment of Gasoline," appears on page 114. Periods, as in February, when flood waters rose to 42 inches, have developed for Mapstone what he refers to as his own "flood technique" involving the dismantling and transporting of all laboratory gear to higher levels or to the attic. During some spells, water has risen 4 inches in 24 hours, while at other times a ½-inch fall has been recorded for eight months. At present all spent shale is being used for the construction of a protective levee bank around the works area.

Glen Davis, N.S.W., Australia, where Mapstone is chief chemist at National Oil Pty., Ltd's shale development lab, is bordered on one side by 30 to 40 miles of practically unexplored wilderness, is 20 miles to the railhead, and 52 miles from the nearest "reasonable" shopping center. Via air to Sydney is 60 miles, by road 153.

Due to this comparative isolation, classes are held here for the Sydney Technical College diploma in chemical engineering and cover the first three years of the six year university course. Mapstone is in charge of the classes which are conducted by the company staff on a part-time basis. He joined National Oil in Glen Davis as lab chemist early in 1941, later was assistant technical chemist to the carbonizing superintendent, assistant chief chemist and since May 1946 has been chief chemist. Mapstone has authored and published more than 40 articles, most of which deal with shale technology.

Mapstone was graduated from Canterbury University College, University of New Zealand with a B.S. in 1939 and took top honors when he got his M.S. in 1940. He is a second generation New Zealander and was born in Christchurch, New Zealand. The Mapstones have what he calls a "pigeon pair"—a boy of five and a year-old daughter.

The TERRY TURBINE



SPECIAL PURPOSE TURBINE

FOR OPERATION UNDER ALL THESE CONDITIONS:

1. Straight, high-pressure, condensing
2. Straight, low-pressure, condensing — putting to work excess low-pressure steam.
3. Mixed pressure — using the low-pressure steam available, with only enough high-pressure steam required to drive the compressor
4. Condensing bleeder operation — providing clean, low-pressure steam for heating or process work

. . . and the speed under any of these conditions can be varied from 2800 to 4750 rpm.

This is but one example of many unusual combinations developed by Terry to meet out-of-the-ordinary requirements in turbines up to 2000 hp. Information on a special-purpose turbine for your specific requirements will be gladly furnished.

T1177

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

Need special high pressure gaskets such as these?

We tailor them to your specifications

If you require high pressure gaskets made to extremely close tolerances—for service exceeding 10,000 psi, for example—and fabricated to any desired diameter or cross-section, why not look into the special service that Goetze offers for making these gaskets to your order.

The gaskets shown above are typical of the wide variety for high pressure service that have been made to order for Goetze customers. The flare type gasket with bellows action illustrated at upper right is but one example of what Goetze "know-how" can accomplish.

Goetze has had over sixty years of experience in making specialized metallic gaskets for industry's most complex jobs. Modern machines—many of them specially designed and built by Goetze—enable Goetze craftsmen to produce gaskets of any required design, shape or size... and deliver them with remarkable promptness.

For further information about Johns-Manville Goetze gaskets, write for a copy of the new Goetze Gasket Catalog. Or send us a drawing or template for assistance on your specific problem. Address Johns-Manville, Box 290, New York 16, N. Y.

Johns-Manville Goetze GASKETS

THERE'S A JOHNS-MANVILLE PACKING AND GASKET FOR EVERY SERVICE.

HOW TO DO IT

HOW TO—

Install Types of Mineral Wool Insulation

SIX methods of installing the felt, blanket, block or board forms of mineral wool insulation are illustrated in the sketches. These approved methods are of particular value to plant engineers, superintendents, and maintenance foremen, who are concerned with the operation of high-temperature equipment.

The sketch of Figure 1 shows felt, block or board insulation attached by welding with stud gun after the insulation is in place. The heated surface is indicated by *A*. *B* is the insulation, and the large head studs are labeled *C*. In Figure 2, *A* is the heated surface; *B*, the clip angles; *C*, blanket insulation; *D*, tie wires from clip angles to metal mesh facings, and *E*, lacing wire between blankets.

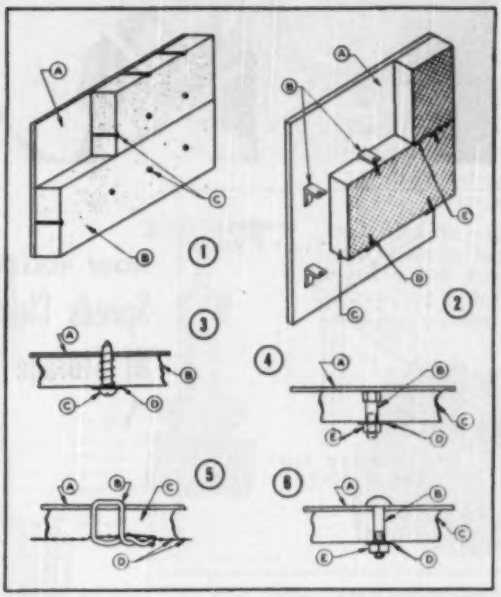


Figure 3 illustrates the method of attaching felt, block or board insulation to light gage metal surface by using sheet metal screws and washers. The heated surface is labeled *A*; insulation, *B*; screws, *C*; and washers, *D*. How to attach felt, block or board insulation by bolts with heads welded to the metal surfaces is shown in Figure 4. The heated surface is *A*; bolt, *B*; mineral wool insulation, *C*; washer, *D*, and nut, *E*.

The method of installing blanket insulation, held on by hairpin wires through twin holes in the metal surfaces, is illustrated in Figure 5. *A* is the heated surface; *B*, hairpin wire; *C*, insulation, and *D*, metal mesh. Figure 6 illustrates the method of installing felt, block or board insulation by bolts through drilled holes. The heated surface is *A*; bolt, *B*; insulation, *C*; washer, *D*, and nut *E*.

Sketches and material courtesy of the Industrial Mineral Wool Institute, 441 Lexington Ave., New York.

HOW—

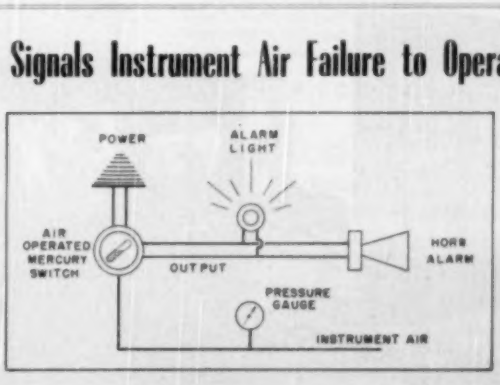
Switch Device Aids Plant Safety Program

THE Plains Plant attained a record in January, 1950, of 3 million man hours worked without sustaining a disabling or lost-time injury. The record earned the National Safety Council's Distinguished Service to Safety award.

One of the reasons for prevention of injuries in the plant is a special safety device demonstrated by Willie Totman in the photograph. When an employe is operating a grinding machine, he wears a face shield or goggles to protect his eyes. All such machines at the plant use this safety device. To remind the employe to wear the shield, machines are turned on and off by lifting and replacing the shield

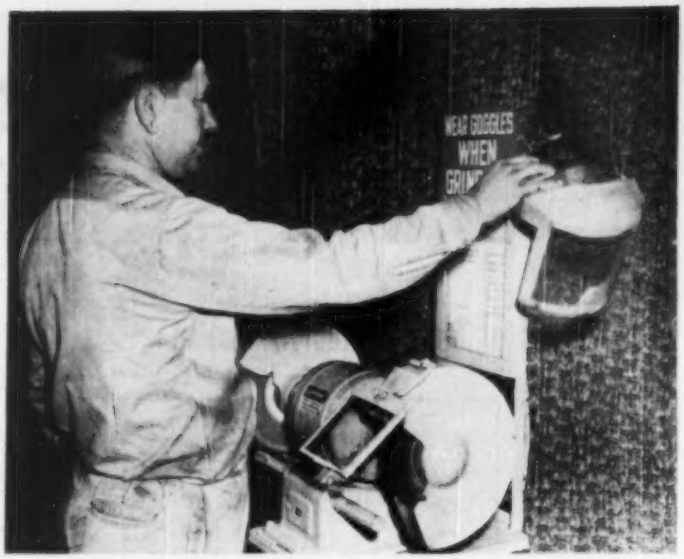
HOW—Alarm Signals Instrument Air Failure to Operator

TO notify operating personnel immediately when instrument air pressure falls to a predetermined minimum value in a process unit, a signal light and a horn alarm has been installed as indicated in the sketch. When the instrument air pressure reaches the predetermined minimum level, the air-operated mercury switch closes, which lights the alarm light on the instrument panel of the unit and sounds the horn alarm.



This equipment provides the operators with the opportunity to correct the trouble causing the low instrument pressure, or time to switch over to an auxiliary or emergency supply of air. Action of the equipment prevents serious upset of the process unit.

Sketch and material courtesy of "Coin Your Ideas" Committee, Esso Standard Oil Company, Louisiana Division, Baton Rouge. Suggestion submitted by Alton T. Barrett and Lawrence J. Bourg, instrument mechanics, meter and instrument department.



It is a much simpler task to heed the safety sign, warning operators to wear goggles when grinding, if the goggles or mask must be lifted off the switch to start the grinder.

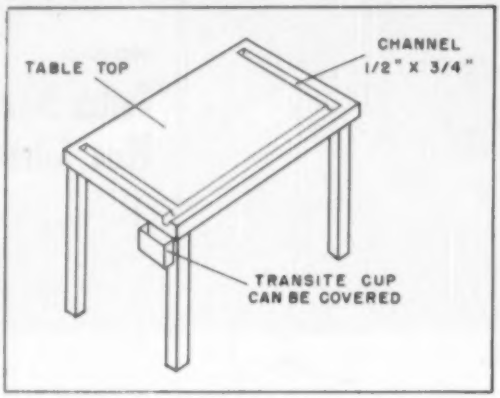
on the switch, which is located above the machine.

The Plains Plant, government-owned plant for the production of butadiene, is operated by Phillips Chemical Company, wholly-owned subsidiary of Phillips Petroleum Company. (Photograph and material, courtesy of *Philnews*, August, 1950.)

HOW TO—
Eliminate the Waste of Mercury

SMALL channels cut around the edges of table tops where mercury is used in filling gauges, etc., prevents spilled mercury from falling to the floor and being wasted. The mercury drains down the channel in the table into a transite cup at one corner, from which it can be recovered. The cup can be provided with a cover.

The table, pictured in the sketch, aids in decreasing the concentration of mercury vapor in the air to a safe level. When spilled mercury reaches the floor and is ground underfoot, the resulting vaporization causes the surrounding air to become toxic.

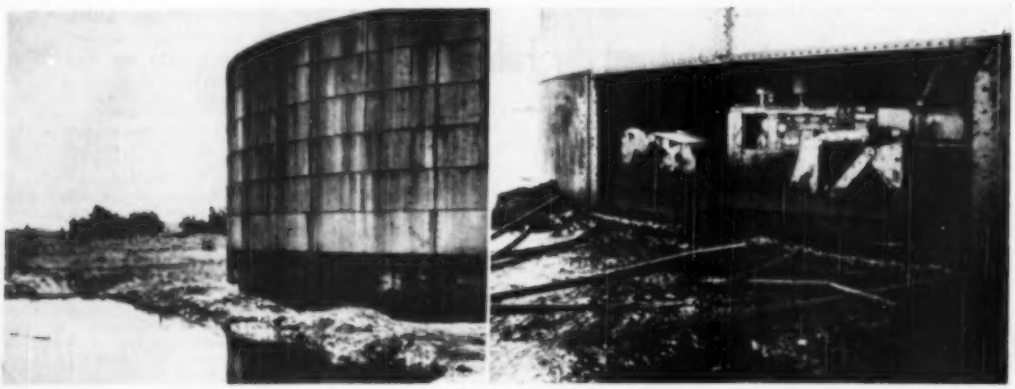


Sketch and material courtesy of "Coin Your Ideas" Committee, Esso Standard Oil Company, Louisiana Division, Baton Rouge. Suggestion submitted by William H. Behrnes, first class carpenter, carpenter department.

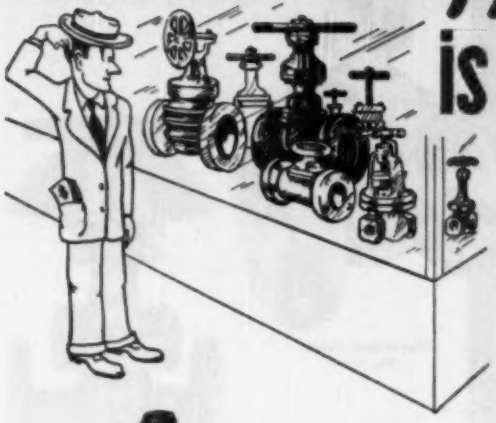
HOW BULLDOZER—
Speeds Cleaning Of Storage Tanks

AMONG the various methods that have been used to clean the bottoms from large crude oil storage tanks, one of the most successful is illustrated in the three photographs. These photographs show a tractor-dozer at work in an 80,000-barrel storage tank of Cos-

Lower left—Bulldozer cleaning out 80,000-barrel tank through opening made by removing side plate. Bottoms are pushed into the pit alongside the tank. Below right — Closeup of tractor in tank during cleanout.



"Window Shopping" for Valves is poor economy



Reading advertisements is like "window shopping"—it's a good way to see what's on the market. But don't let it influence you into buying your flow control equipment from different sources.

Because if you buy all your valves from one source you avoid these pitfalls:

Complications in stocking spare valve parts.

Difficulties that confront the maintenance department in making repairs on a variety of valves.

The necessity of carrying a much larger stock of repair parts.

The chances of installing valves that are not backed by adequate engineering service.

By offering the *only* COMPLETE line of valves available to Industry today, Powell makes this possible. And if you consult Powell Engineers and select the right valve to suit each individual service, your flow control problems are ended.

Fig. 6079 M.O.—Class 600-pound Cast Steel Gate Valve for Pipe Line Service. Has flanged ends and bolted flanged bonnet. Motor operated. Also available in Classes 150, 300, and 400 pounds.

Fig. 375—200-pound Bronze Gate Valve. Screwed ends, union bonnet, inside screw rising stem and renewable "Powellium" wear-resisting nickel-bronze disc.

Fig. 1561—Class 150-pound Cast Steel Swing Check Valve with flanged ends and bolted cap.

Fig. 1793—Large 125-pound Iron Body Bronze Mounted Gate Valve with flanged ends, bolted flanged yoke, outside screw rising stem and tapered solid wedge. Also available in All Iron.

The Complete Powell Line includes Globe, Angle, "Y", Gate, Check, Non-return, Relief and Flush Bottom Tank Valves in Bronze, Iron, Steel and a wide range of Corrosion-resistant metals and alloys.

Ask your nearest Distributor—or write direct

The WM. POWELL Co., 2525 Spring Grove Ave.
P. O. Box 106, Station B, Cincinnati 22, Ohio
DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

POWELL VALVES

ALOYCO 20...

the *one best alloy* for valves in sulfuric acid service!

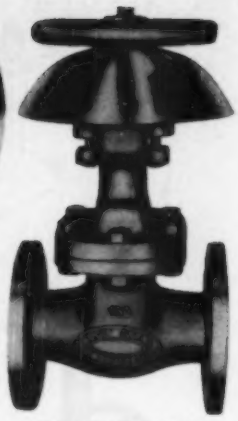
ALOYCO 20 is frequently referred to as a *super* corrosion-resistant alloy. This is due to its unequalled resistance to hot and cold sulfuric acid in various concentrations, as well as to many other acids.

Valves are manufactured in Aloyco 20 in a complete range of types and sizes, screwed and flanged ends, in 150, 300 and 600 lb. pressure classes. Illustrated are a few of the more popular valves that are used in great numbers by plants producing materials such as fertilizers, plastics, rayon, soap, synthetic rubber, explosives, coal tar and oil refinery products. In short—Aloyco 20 valves have an application wherever Sulfuric Acid is used.

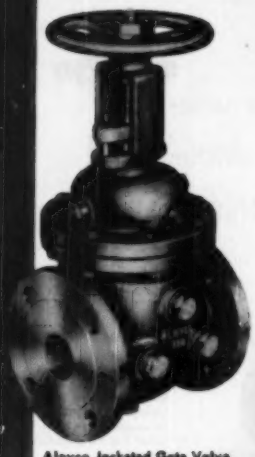
Aloyco 20 is practically unaffected in any concentration of H_2SO_4 at room temperatures. It is also adequately resistant at the boiling point up to 30% acid strength. In concentrations between 30% and 93%, temperature is an influencing factor. Aloyco 20 is also strongly resistant to the effects of high strength sodium hydroxide, hot acetic acid, acetic anhydride vapors and hot nitric-sulfuric solutions.

Our metallurgists will gladly confer with you regarding the application of Aloyco 20 and the many other Aloyco corrosion-resistant alloys —to assure your using the *one best alloy* to meet your particular requirements.

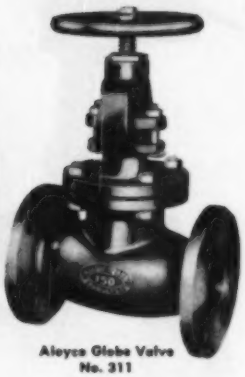
Aloyco Gate Valve
No. 111



Aloyco Acid Shield Valve
No. 111-AS



Aloyco Jacketed Gate Valve
No. 1105



Aloyco Globe Valve
No. 311

Aloyco Check Valve
No. 371

Aloyco Needle Valve
No. 62½

ALLOY STEEL PRODUCTS CO., Inc.

1303 W. ELIZABETH AVE., LINDEN, NEW JERSEY

ATLANTA — CHICAGO — HOUSTON — LOS ANGELES
NEW YORK — PITTSBURGH — WILMINGTON

den Petroleum Corporation, Big Spring, Texas.

This method of tank cleaning was instigated at the refinery some four years ago by E. B. McCormick, chief engineer. Operation was begun with only one tractor, but since the method has proven so successful, a second has been added for this type work.

Preparatory to cleaning a tank, the buldozer is used to dig a pit alongside the tank. Then, when a plate has been removed from the tank, the bulldozer enters the tank and pushes the materials that have settled from the oil in the tank out through the opening into the pit. From the pit, the material can be transported to another location for burning or use in topping roadways, etc.

Since this method has been in use at the plant, representatives from other oil companies, some from as far away as Canada and the West Coast, have inspected the method and many have adopted it for use in their operations.

Photos courtesy, H. A. Swan, Central Texas Machinery Company, Abilene, Texas.

Bulldozer at work in the 80,000-barrel tank. This equipment quickly and easily performs a job that previously was difficult and time-consuming.

HOW TO IMPROVE—

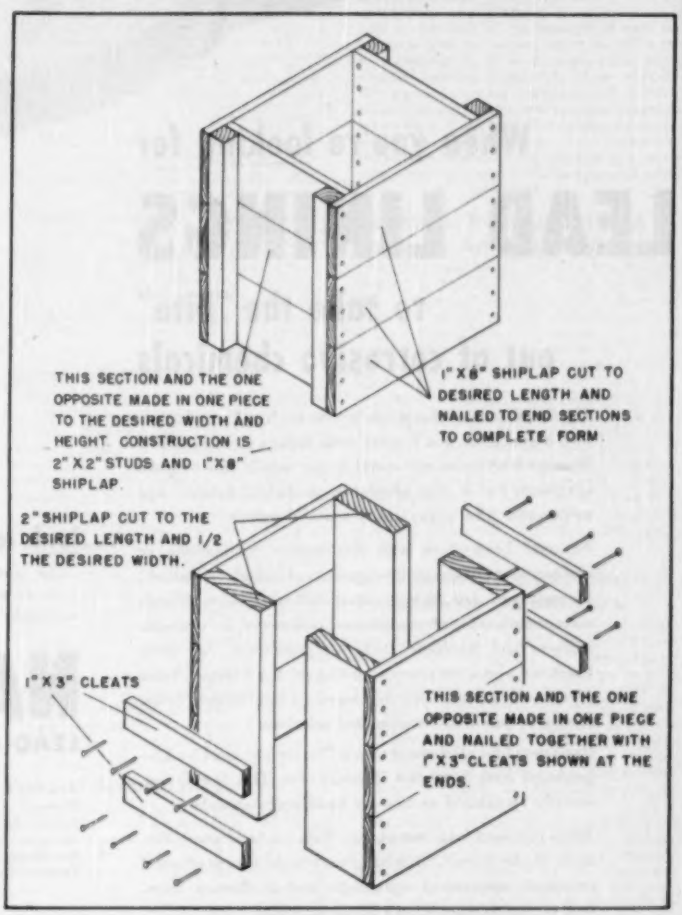
Concrete Forms for Pipe Supports

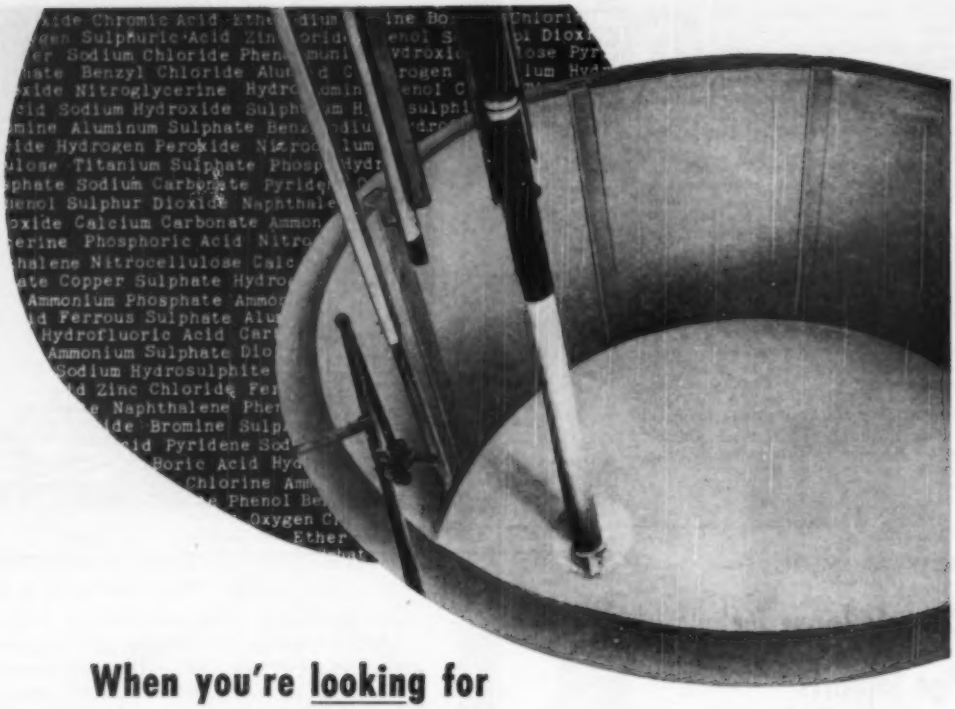
WHEN concrete pipe supports or piers of any type are to be constructed, forms are needed to hold the concrete. Previously, forms were built of 1-by-8-inch shiplap of the desired length, nailed to 2-by-2-inch studs. The sides of the form also were made of 1-by-8-inch shiplap. When this form was stripped off the pier, a number of manhours were lost and the material in the form was damaged and discarded in most instances. These losses are attributed to the construction of the form.

The new forms are made in two identical sections. Like the earlier forms, they are made from 1-by-8-inch shiplap cut to the desired length; however, they are nailed to 2-inch pieces of stock lumber cut to one-half the desired width of the form as shown in the accompanying drawing, instead of 2-by-2-inch studs. To join the sections into the complete form, two 1-by-3-inch wooden cleats are nailed across the joints on each end section. These cleats are pulled off to remove the form.

The new form can be re-used instead of being discarded because of damage in stripping. When a job requires more piers than can be poured in one day, the job can be completed by re-use of the supply of forms constructed for the job on the first day. In addition to the advantage of being stripped without damage, this form can be stripped in less time than that required for the old form.

Sketch and material courtesy of "Coin Your Ideas" Committee, Esso Standard Oil Company, Louisiana Division, Baton Rouge. Suggestion submitted by Thomas E. Robb, first class carpenter, carpenter department.


THIS SECTION AND THE ONE OPPOSITE MADE IN ONE PIECE TO THE DESIRED WIDTH AND HEIGHT. CONSTRUCTION IS 2" X 2" STUDS AND 1" X 8" SHIPLAP.
1" X 8" SHIPLAP CUT TO DESIRED LENGTH AND NAILED TO END SECTIONS TO COMPLETE FORM.
2" SHIPLAP CUT TO THE DESIRED LENGTH AND 1/2 THE DESIRED WIDTH.
1" X 3" CLEATS
THIS SECTION AND THE ONE OPPOSITE MADE IN ONE PIECE AND NAILED TOGETHER WITH 1" X 3" CLEATS SHOWN AT THE ENDS.



When you're looking for

LEAD LININGS

to take the "bite" out of corrosive chemicals

If your processing operations involve the handling of corrosive chemicals... you'll want tank linings of lead. Why? Because lead is the *able* metal. It not only is *able* to resist corrosion, but is also adapt*able*, work*able*, dur*able*, and salvage*able* after many, many years of service.

National Lead sheet with this unique combination of abilities is available in these grades: *chemical*, "standard" for most uses; *tellurium*, for increased corrosion resistance and strength at high temperatures; *antimonial*, for strength, stiffness and hardness; *tellurium-antimonial*, for extra hardness where erosion or cutting is a problem; *Nalco Metal*, a new lead alloy developed to give longer, better service in handling chromic acid solutions.

Basic metal for all these grades is "St. Joe chemical lead,"—produced from Southeast Missouri ores. This lead is universally recognized as best for handling chemicals.

When you need lead linings, buy National Lead sheet. For, as the leader in lead, National gives you the benefit of metal resources, mechanical equipment, and production know-how second to none. Plants in all principal cities.

...look to the Leader in Lead

...for everything from lead pipe...valves...sheet ...and lead-lined or lead-covered equipment...to a complete acid recovery plant

NATIONAL

LEAD COMPANY

New York 6; Atlanta; Baltimore 3; Buffalo 3; Chicago 8; Cincinnati 3; Cleveland 13; Philadelphia 25; Pittsburgh 12; St. Louis 1; Boston 6 (National Lead Company of Mass.); Los Angeles 23 (Morris P. Kirk & Son, Inc.); Toronto, Canada (Canada Metal Co. Ltd.)

Dutch Boy PRODUCTS

Trademarks Reg. U. S. Pat. Off.

The MONTH... in the INDUSTRY

Hugh Banquet One of Features of API Session Slated Next Month

Los Angeles will be the host city for the 30th Annual Meeting of the American Petroleum Institute November 13-16. Thousands of oil and gas men, representing every phase of the industry and from every section of the country, will attend this, the first such meeting held in a West Coast city since 1941, and the first in Los Angeles since 1935.

The program calls for committee sessions, group meetings, panels and forums to cover all divisions of the petroleum industry. To accommodate the influx of oil men, the Biltmore and Ambassador Hotels will be used for the heavy schedule of committee and group sessions, and the Biltmore Theatre, adjacent to the Biltmore Hotel, will be used for general sessions.

W. Alton Jones, president of Cities Service Company and chairman of the API board of directors, will preside over the meeting's two general sessions, which are scheduled for 9:30 a.m. Wednesday and Thursday, November 15 and 16.

Highlighting the first general session Wednesday morning will be presentation of the API Gold Medal for Distinguished Achievement, which was last year bestowed on J. Howard Pew, director and retired president of Sun Oil Company. This year's recipient has not yet been named. Frank M. Porter, API president, will address the meeting.

Industrial leaders scheduled to speak at Thursday's general session are Benjamin F. Fairless, president of United States Steel Corporation, New York, and Reese H. Taylor, president of Union Oil Company of California.

A banquet for 2500 guests is being planned for Wednesday night, November 15, at the Hollywood Palladium Ball Room. Arrangements for the event, which is being sponsored by West Coast oil men, are being handled by a local committee headed by Arthur C. Stewart, of Union Oil Company of California.

API directors will meet Tuesday morning and afternoon, and Wednesday afternoon. The board of councilors will meet Tuesday morning to nominate candidates for election to the board of directors, and will present its report to the first general session, Wednesday morning. The executive committee will have a luncheon meeting Thursday, November 16.

Group and committee sessions (chairmen shown, when name available) include:

Thursday, November 9—Subcommittee on Sludges and Clays, J. A. Fowler. On Waste Gases and Dusts, D. G. Stevens. On Chemical Wastes, J. H. Easthagen. On Oil-Water Separation, R. N. Giles. On Sampling and Testing (Waste Disposal), R. J. Austin. On Emulsions, W. E. Soden.

Friday, November 10—Committee on Disposal of Refinery Wastes, L. C. Burroughs. Manufacturers' Subcommittee on Safety and Relief Valves, L. P. Stillman. Joint Subcommittee on Field-Assembled Vessels, W. L. Bowler. Subcommittee of Refinery Inspection Supervisors, H. F. West.

Saturday, November 11—Subcommittee on Emission Spectroscopy, R. O. Clark. On Tank Accessories and Cleanouts, E. E. Kerns. On Corrosion, M. S. Northrup. On Oxygenated Compounds, W. H. Jones. On X-Ray Defraction, E. B. Tucker. On Pressure-Relieving Systems, J. C. Souder. Manufacturers' Subcommittee on Refinery Valves, W. P. Kliment. Subcommittee on Nitrogen Determination, G. R. Lake. On Trace Elements, Harry Levin.

Sunday, November 12—Committee on Petroleum Products, H. W. Field. Subcommittee on Unfired Pressure Vessels, N. J. Rees.

Monday, November 13—Group Session on Accident Prevention, F. R. McLean. Subcommittee on Mechanical Equipment, E. F. Voss. On Valves, Homer Reed. Committee on Analytical Research, E. L. Baldeschwieler. Automotive Research Committee, D. P. Barnard. Committee on Refinery Equipment, Bonner H. Barnes. Advisory Committee, Division of Refining, John W. Newton.

Tuesday, November 14—Group Session on Fire Protection. Group Session on Lubrication, W. M. Murray. Program Committee, Division of Refining, W. M. Holaday. Subcommittee on Electrical Equipment, L. M. Goldsmith. General Committee, Division of Refining, Chester F. Smith. Nominating Committee, Division of Refining, G. L. Neely.

Wednesday, November 15—Group Session of Division of Refining, Chester F. Smith.

Special Trains for API

Two special trains will be required to take Texas oil men and their wives to Los Angeles for the API annual sessions, these in addition to hundreds of others who have reservations on regular trains and planes. The two API specials, to be run by the Santa Fe out of Houston with cars picked up at Fort Worth and Dallas, are scheduled to leave Houston at 8 p.m., November 10, arriving in Los Angeles at 8 a.m., November 12. Returning they will leave Los Angeles at 6 p.m., Thursday, November 16, arriving in Houston 8 a.m., Saturday, November 18.

Another API special will move out of New York by New York Central and Santa Fe from Chicago. One Santa Fe Super Chief out of Chicago will be almost exclusively occupied by API-bound passengers. A Santa Fe special also will be run out of Tulsa.

Tells of Scholarships

A college scholarship plan for sons and daughters of Continental Oil Company employes was announced last month by President L. F. McCollum. The program of ten $500 scholarship awards will be begin in 1951. Full details of the plan are to be announced.

SAFETY RECORD—George S. Dunham, left, vice chairman of the manufacturing committee, Socony-Vacuum Oil Company, Inc., and J. L. Risinger, safety director, with a white china elephant returned several days ago to the company's New York headquarters, with completion of more than a year without an accident at the company's Atlas Works in Buffalo. The elephant circulated in the Buffalo refinery for about three years, lodging for a month at a time on the desk of the manager of each department with the poorest safety record in the preceding month. A. A. Krueger, plant safety director, held the elephant for three accident-free months before turning it over to R. B. Price, refinery superintendent, who retained possession for another 12 accident-free months before returning the elephant to New York. Employes of the refinery received individual gifts at a safety rally in the refinery to mark their unusual safety record.

Southern Regional NGAA To Have Annual Meeting

Actual operating problems will be discussed at the Southern Regional Meeting of Natural Gasoline Association of America at the Blackstone Hotel, Tyler, Texas, Friday, October 27. This annual affair is held in cooperation with the East Texas Natural Gasoline Men's Club.

John P. Tucker, president of the ETNG, Arkansas Fuel Oil Company, and Charles A. Schwartz, Caska Corporation, Quitman, are co-chairmen of the program committee. L. L. Dresser, Dresser Engineering Company, Tulsa, and president of the Natural Gasoline Supply Men's Association, has announced that the NGSMA will again be host at a social hour.

U. S. Loan Is Indirect Aid To Mexican Oil Industry

Indirectly, the government of Mexico has obtained from the U. S. government a loan for expanding its nationalized petroleum industry. Although no part of the $150 million loan made recently by the U. S. Export-Import Bank is earmarked for oil development, the loan will free substantial Mexican government revenue that otherwise would have had to be used for non-oil projects and permit it to be devoted to oil industry use.

By excluding petroleum developments from the specific list of projects eligible for line-of-credit, the State Department maintained its policy of no loans for foreign oil projects. American oil companies, majors and independents, have

The MONTH...

long actively opposed lending money to Mexico for oil development. They asserted that U. S. private capital would help develop Mexico's oil if the industry were re-opened to private enterprise as in the U. S.

Petroleum Chemistry Award Goes to Dr. Schmerling

Dr. Louis Schmerling, a research chemist with Universal Oil Products Company, Chicago, has been selected as the recipient of the 1951 Precision Scientific Company award in petroleum chemistry. The $1000 cash prize which is administered by ACS was created to recognize, encourage and stimulate outstanding research achievements in the field of petroleum chemistry in the U. S. and Canada. Presentation will be in April, 1951.

Schmerling

Among Dr. Schmerling's accomplishments is the clarification of the mechanism of alkylation of isoparaffins. He has authored about 30 scientific publications and holds 70 U. S. patents. In 1947 he was selected as the first winner of the triennial $3000 Ipatieff Prize in Chemistry for his outstanding experimental work in the field of catalysis.

Dr. Schmerling, 38, was born in Milwaukee, Wis., was granted his Bachelor of Science in chemistry from the University of Wisconsin in 1932 and his Ph.D. from Northwestern University in 1935.

Annual A.I.Ch.E. Meeting Is Scheduled for December

About 1500 engineers and executives of the chemical and allied industries are expected in Columbus, Ohio, December 3-6, for the annual meeting of AIChE.

Among the 42 papers to be presented will be two dealing with practical mixing techniques and heat-transfer problems. Engineering calculations for a pseudo-plastic fluid will be presented in a paper dealing with pressure drop of fluid polystyrene in conduits.

Vapor-liquid equilibria will be one of the main topics at the symposium on phase equilibria. Eight papers, covering a range of subjects from hydrocarbons to hydrazine-water mixtures, will be read.

DPA Gives Oil Industry Separate Control Agency

The Defense Petroleum Agency, now being formally established by the Department of Interior will give the oil industry its own control agency, similar to the PAW. Organizing the agency and acting as consultant to Interior Secretary Chapman will be J. R. Parten, Houston oilman and president of the Woodley Petroleum Company who was drafted by President Truman for the job.

The agency, which will be separate from the other agencies working in the new defense program, will be directly responsible to Chapman. Included in its functions will be assigning allocations and priorities for oil and oil products, approving loan guarantees for expanding productions, recommending price policies for the industry's products, and recommending regulations on petroleum consumption.

Chapman in a meeting with the National Petroleum Council pledged to do all in his power to leave the same competitive relationships among the units of oil and gas industry as are now existing. This promise met a request by NPC Chairman Walter S. Hallanan who said the industry wanted assurance that once the emergency was over, they could continue free from any temporary or permanent federal control.

F-W International Setup To Be Headed by L. A. Swem

Foster Wheeler Corporation, New York, has appointed Lee Allan Swem, as vice president in charge of the newly formed international division. This division will be responsible for foreign business of the corporation and will coordinate the activities of subsidiary companies in Canada, England and France.

Swem joined Foster Wheeler Corporation in 1936 as patent counsel and was elected vice president in charge of the legal department in 1948.

Inventory Control Order Covers Refining Chemicals

Chemicals essential to the oil industry as well as natural and synthetic rubber were included among the materials placed under inventory controls in September by the National Production Authority.

The NPA order also covered a wide range of materials, such as iron and steel in various forms, which are of great importance in the oil industry's equipment needs.

Not restricted to the manufacturing level, the order extends to distributors and retailers, excluding only ultimate consumers buying for personal or household use.

Included among the chemicals listed in the order are caustic soda and soda ash, materials vital to refining which are short of supply in certain sections of the country due to work stoppage. Other chemicals include industrial alcohol, benzene, gaseous and liquid chlorine and crude and refined glycerine.

Carnegie Tech to Celebrate

Carnegie Institute of Technology will inaugurate its fourth president, Dr. J. C. Warner, and will celebrate it fiftieth anniversary October 27-28.

Saturday, in celebration of its anniversary, Carnegie will be toasted by Charles E. Wilson, president of General Motors Corporation and member of the class of 1909.

Growing Importance of Instrumentation Stressed at Buffalo Meet and Exhibit

The extraordinary increase in importance of instrumentation in industry and science was clearly reflected in the exhibits of the fifth National Instrument Conference and Exhibit held in Buffalo, N. Y., September 18-22. The conference was jointly sponsored by the Instrument Society of America, the Industrial Instruments and Regulators Division of the American Society of Mechanical Engineers, the American Institute of Physics, the Instruments and Measurements Committee of the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the Scientific Apparatus Makers Association.

Although the first instrument exhibit and conference was held in 1946, the 1950 version assumed the stature of a mature national institution. More than 140 exhibits were included. Several thousand instrument engineers, plant designers, and others attended.

A program consisting of sessions on instrument maintenance, inspection and gauging, instrumentation for testing, transportation instruments and instrumentation for production processes, was presented.

R. J. S. Pigott, President of the instrument Society, in urging attendance at the meeting, pointed out that "Costs must be cut so that prices may be reduced without wiping out profits. High wages must be kept high. To meet these demands for national defense industry must plan increased outputs per worker."

"Modern industry depends on automatic controls, which are more accurate and more dependable than human beings. More and more, the tedious tasks in industry are performed by instruments while skilled instrument men install and maintain them."

The Instrument Society's unique objective "to advance the arts and sciences connected with the theory, design, manufacture and use of instruments in the various sciences and technologies" requires that the Society be at the service of and cooperate with many other technical, scientific and engineering societies in the development of the principles of measurement and the use of measuring and controlling instruments, officials pointed out.

It is not strange that the general public, including many persons closely associated with engineering projects, are relatively unaware of the wide-spread and complex applications of measuring and controlling instruments throughout science and industry. During World War II, the instrument industry found that it had to deal with nearly three dozen separate divisions of the War Production Board. This strange condition is now being rapidly altered and improved. The Instrument Society enjoys the cooperation of older and stronger engineering and scientific institutions.

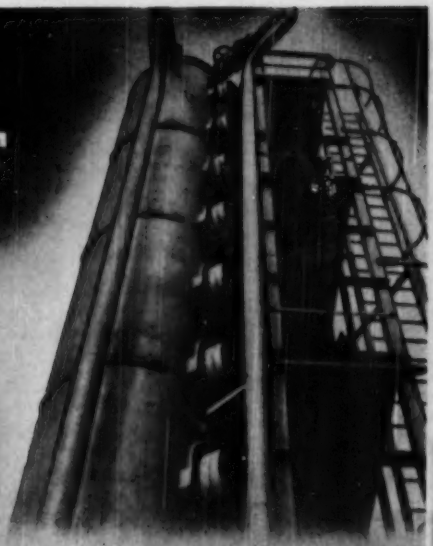
Speakers at the conference sessions pointed out that automatic controls can see more, hear more, think faster and toil more tirelessly than human beings.

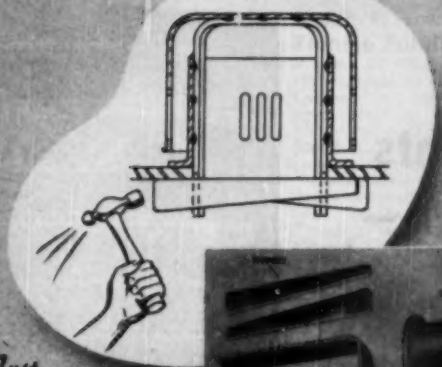
"The use of instruments enables industries to obtain better yields of purer

CUT TOWER CLEANOUT TIME

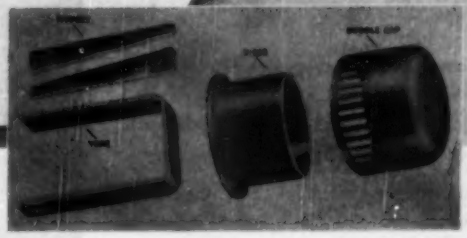
with *Le Jons*

BUBBLE CAP ASSEMBLY





Just Hammer Wedges In or Out



The new Le Jons bubble cap assembly is also showing impressive savings in tray construction cost. The cap, riser and yoke, shown in the exploded view, come securely welded together. To install just hammer in wedges and bend over slightly to lock. No bolts or nuts. No costly flaring or welding of risers. Assemblies furnished in any workable metal, style and size of cap. Let us send you full details.

Offering unprecedented simplicity, the new Le Jons method of assembling bubble caps is clearly effecting substantial maintenance savings. For instance, installation records show that cleanout and inspection time has been materially shortened; the bubble caps can be removed by merely hammering out the wedges. It has been repeatedly demonstrated that the simplicity and tightness of the assembly, together with its automatic alignment of caps, maintain operating efficiency in the tower, and thus lessen down time.

PSC EQUIPMENT IS "ALLOY RIGHT"

Over 200 STANDARD STYLES of Caps and Risers, without Die Cost

With the dies on hand, we not only make prompt delivery but also save many customers the cost of dies. Special caps promptly designed. Send blue prints.

Send for

BUBBLE CAP BULLETIN 21

The largest compilation of engineering data on bubble caps in printed form. Also drawings for use in determining methods of tray assembly. BULLETIN 31 describes Le Jons assembly.

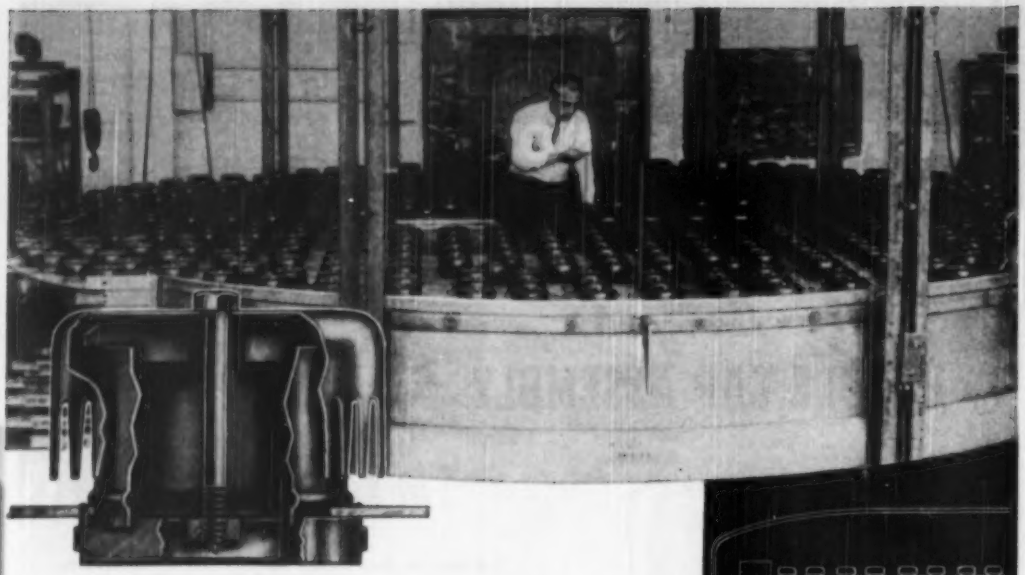
LICENSED UNDER PATENT NO. 2480982

THE PRESSED STEEL COMPANY

of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆



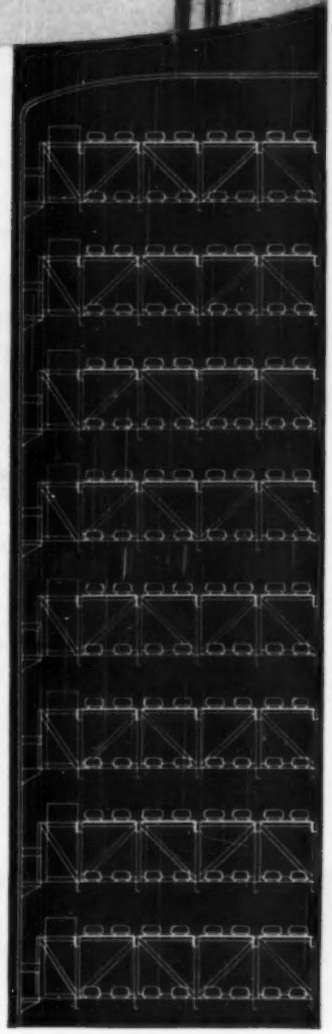
proven improvements in bubble tray design—

One truss for every two trays . . . with every alternate tray level free of major supports — this is the new bridge-type truss design that makes Gilbarco Duo-Level bubble trays faster to install, far easier to clean, and more rigid with lighter weight.

New cap assemblies are designed for quick, easy removal by one man working from the top side. There are no flanges or projecting edges around holes to slow up cleaning operations.

A new clamp design with improved packing protection minimizes joint leakage without causing distortion of the trays under temperature changes.

Duo-Level bubble trays, fabricated of alloy metals, are adaptable to refinery requirements either as new equipment or replacements. Gilbarco's large staff of engineers is at your service to demonstrate how Gilbarco bubble trays can be fabricated to meet the requirements of your process design.



Gilbarco

GILBERT & BARKER MFG. CO.

West Springfield, Mass. Toronto, Canada

Established in 1865

products from poorer raw materials," they said.

"In the chemical and petroleum industries, the complexity and velocity of the processes have outrun the ability of human operators to control them. Industrial instruments are acknowledged to be the key to large scale production problems. Precision measuring, testing and controlling instruments made possible such processes as catalytic cracking, hydrogenation, polymerization, and others."

Cleveland Named to Handle Phillips Public Relations

Chester W. Cleveland of Chicago has been named by Phillips Petroleum Company, to the newly created post of director of public relations. Cleveland, who will make his headquarters in Bartlesville, Okla., is a 28-year veteran of newspaper, magazine, and public relations fields. He will centralize all matters pertaining to company publicity, press relations, and the preparation and handling of public statements such as news releases, magazine articles, and communications to stockholders.

The company's public relations department has been renamed the "advertising department" and will handle all company advertising, together with the publications produced in that department.

R. C. Jopling, heretofore vice president public relations, becomes vice president advertising, and continues in charge of the company's Washington, D. C. office. F. L. Rice, heretofore manager public relations department, becomes manager advertising department.

California Standard Head Criticizes Anti-Trust Suit

Anti-trust suits directed at breaking up "bigness" were criticized by T. S. Petersen, president of Standard Oil Company of California, in a talk at San Francisco.

Speaking of the suit filed in May by the anti-trust division of the Department of Justice against California Standard and six other large West Coast oil companies Petersen declared:

"As the war in the Pacific has developed, the military services have turned to us and the other larger companies for the flood of petroleum products we could supply because of our size, and the extensive nature of our facilities. Yet, this size and our operation of these facilities are called wrong by the anti-trust suit."

He said that Standard itself had spent more than $500 million in the last five years to find new oil and build new facilities.

Pipkin Is Named to Head Texaco Public Relations

James H. Pipkin, former assistant to the chairman of the board of The Texas Company, has been named general manager, Industrial and Public Relations. He succeeds James Tanham, retired. James W. Foley has replaced Pipkin as assistant to the chairman of the board.

Pipkin received a Bachelor of Law degree from the University of Texas in 1931, and in 1934 joined The Texas Company in the legal department in Houston. He was transferred to New York in 1941 as assistant to the executive vice president. He was named assistant to the president in 1944, and was advanced to assistant to the chairman of the board in September of last year.

Foley was graduated from Texas A. & M. College in 1932 with a degree in petroleum engineering. He moved to New York in 1949 as assistant to the vice president.

THE OIL MAN'S CALENDAR

1950 OCT.	
11–13	Instrumentation for Process Industries, Fifth Annual Symposium, Texas A. & M. College, College Station, Texas.
12–13	Western Petroleum Refiners Association, Regional Meeting, Casper Wyo., Gladstone Hotel.
16–20	National Safety Congress, National Safety Council Exposition, Chicago.
15–21	Oil Progress Week.
27	Natural Gasoline Association of America, Southern Regional Meeting, Tyler, Texas, Blackstone Hotel.
30 to Nov. 1	National Lubricating Grease Institute, Annual Meeting, Chicago, Edgewater Beach Hotel.
NOV.	
2- 3	Eighth Annual Pittsburgh Conference on X-Ray and Electron Diffraction, Pittsburgh, Mellon Institute for Industrial Research.
2- 3	Society of Automotive Engineers, Diesel Engine Meeting, Chicago, Hotel Knickerbocker.
9–10	Society of Automotive Engineers, Fuels and Lubricants Meeting, Tulsa, The Mayo.
9–10	California Natural Gasoline Association, 25th Annual Fall Meeting, Los Angeles, Ambassador Hotel.
11–13	Oil Industry Information Committee, Los Angeles, Biltmore Hotel.
13–16	American Petroleum Institute, 30th Annual Meeting, Los Angeles, Biltmore and Ambassador Hotels.
26 to Dec. 1	American Society of Mechanical Engineers, New York, Hotel Statler.
27 to Dec. 2	American Society of Mechanical Engineers, 19th Exposition of Power and Mechanical Engineering, New York, Grand Central Palace.
3- 6	American Institute of Chemical Engineers, Annual Meeting, Columbus, Ohio, Neil House and Deshler-Wallick Hotel.
1950 DEC.	
26–31	American Association for the Advancement of Science, Annual Meeting, Cleveland, Hotel Statler.
1951 JAN.	
8–12	Society of Automotive Engineers, Annual Meeting and Engineering Display, Detroit, Hotel Book-Cadillac.
15–18	Plant Maintenance Show, Cleveland.
FEB.	
28 Mar. 2	Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, William Penn Hotel.
MAR.	
5- 9	American Society for Testing Materials, Spring Meeting and Committee Week, Cincinnati, Ohio.
13–17	National Association of Corrosion Engineers, Annual Conference and Exhibition, New York, Statler Hotel.
APRIL	
1- 3	Western Petroleum Refiners Association, Annual Meeting San Antonio.
16–18	American Society of Lubrication Engineers, Annual Convention and Lubrication Show, Philadelphia, Bellevue-Stratford Hotel.
18–20	National Petroleum Association, Cleveland, Ohio, Hotel Cleveland.
25–27	Natural Gasoline Association of America, Annual Meeting, Tulsa, Mayo Hotel.
30 to May 3	American Petroleum Institute, Division of Refining, Midyear Meeting, Tulsa, Mayo Hotel.
MAY 28 June 6	Third World Petroleum Congress, The Hague-Scheveningen, Netherlands.
JUNE 19–22	American Society for Testing Materials, Annual Meeting, Atlantic City, N. J.

The MONTH...

Advisory Board Appointed For Plant Maintenance Show

A 16-man exhibitors' advisory board has been appointed to assist in the direction of policies for the Plant Maintenance Show and the concurrent conference on plant maintenance techniques at Cleveland, January 15-18. Members of the board represent a cross-section of American industry manufacturing goods to reduce costs of maintenance. L. C. Morrow, consulting editor, *Factory Management and Maintenance*, who will serve as chairman of the conference, has been named chairman of the advisory board.

U. S. Rubber Appoints Brown Chief Engineer of Division

J. Scott Brown, who has been appointed chief engineer for the Naugatuck chemical division, United States Rubber Company, will supervise engineering operation in the synthetic rubber plants operated by the division in Naugatuck, Conn., Port Neches, Texas, and Borger, Texas. He will also supervise engineering activities in the Marvinol vinyl resin plant at Painesville, Ohio, and the Naugatuck chemical plant.

Oil Industry Committee Plans Information Program

An accelerated information program in 1951 was planned by the Oil Industry Information Committee meeting last month in Atlantic City.

Final drafting of the program will be completed at the meeting in Los Angeles in November, at which time it will be recommended to API for approval.

The committee authorized expansion of its publicity-editorial department and the research department. They also authorized a quick survey of public opinion of the oil industry. These results may be available for the November meeting.

Organizational work has been moving swiftly, Miller reported, and the total number of committees in operation is 3,500, an all-time high.

U.S.A. Organizes for Third World Petroleum Congress

The National Committee for the U. S. A. for the Third World Petroleum Congress meeting in The Hague on May 28-June 6, 1951, has elected E. V. Murphree of Standard Oil Development Company, New York, as chairman. Other officers are F. S. Clulow of Shell Oil Company, New York, vice chairman; Paul D. Foote of Gulf Research & Development Company, Pittsburgh, vice chairman; and K. G. Mackenzie of The Texas Company, New York, secretary.

Other members of the executive com-

Wherever pipes meet, permanently

IN THE PETROLEUM FIELD, the right answer to every temperature, pressure and corrosion resistance fittings problem is W-S Screw End and Socket Weld Forged Steel Fittings.

Basic materials are selected from a wide choice of carbon, stainless and alloy steels. Designs are carefully engineered. Fittings are drop forged for strength . . . precision machined for accuracy of finish, and instrument inspected for perfection of threads, sockets, angles and concentricity. Investigate them today.

Write for Bulletin A3-50. For information on Stainless and Alloy Steel Fittings, ask for Bulletin S-1.

SOLD THROUGH LEADING DISTRIBUTORS EVERYWHERE

SPECIFY... W-S FORGED STEEL FITTINGS

DISTRIBUTORS PRODUCTS DIVISION, ROSELLE, NEW JERSEY

WATSON-STILLMAN Established 1848

Designers and Manufacturers of Forged Steel Fittings, Valves, Wire Rope Sheers, Hand Pumps, Jacks, Pipe Benders and Hydraulic Equipment

The MONTH...

mittee are Earl Bartholomew of Ethyl Corporation, Detroit, and W. F. Faragher of Houdry Process Corporation Philadelphia.

O'Brien Appointed Counsel For Cities Service Company

Henry L. O'Brien has been appointed general counsel of Cities Sevice Company and its subsidiaries.

O'Brien has been an officer and director of the company since 1940, and in recent years supervised the disposition by Cities Service of its electric utility properties.

Enters Consulting Field

James L. Sherwin, chief electrical engineer of Arthur G. McKee & Company, has resigned to re-establish a consulting electrical engineering service in Cleveland. His office will undertake investigation, reporting, planning and estimating for reconversion of existing or new oil refinery and industrial plant electrification systems.

Orval Lewis Joins C. F. Braun

Orval L. Lewis completed his work in charge of mechanical design department of Engineering & Construction division, Jones & Laughlin Supply Company, and has joined C. F. Braun & Company at Alhambra, Calif., as staff engineer. He is publicity secretary for the Petroleum division of ASME.

Construction Items

Canadian Oil to Construct $18 Million Ontario Plant

Canadian Oil Refineries, a subsidiary of Canadian Oil Companies, plans construction of an $18 million refinery at Froomfield, Ont., two miles from Sarnia. The plant will process 5 million barrels annually of Alberta crude reaching the refinery by tanker from the eastern terminus of the Interprovincial pipe line, in which the parent company has a $900,000 interest.

Stone & Webster Engineering Corporation has been appointed project manager for the plant, which is scheduled to begin operations in April, 1952.

The refinery will include a 20,000-barrel-per-day capacity combined atmospheric and vacuum distillation unit, catalytic reforming unit, catalytic cracking unit, catalytic polymerization unit, fractionators for production of butane and commercial propane, and an installation to desulfurize fuel gas. Further construction planned is storage for crude and gasoline totaling 900,000 barrels.

Modernization Program Set For Bay's Chalmette Plant

Plans for the complete modernization of Bay Petroleum Corporation's Chalmette, La., refinery call for installation of a 6000-barrel-per-day Fluid catalytic

The MONTH...

cracking unit, being designed by Universal Oil Products Company.

Contractor for construction of the new unit and revamping existing facilities is Procon, Inc. Completion is scheduled for the latter part of 1951.

Present crude capacity of 12,000 barrels per day will be increased to 16,000 barrels per day by the new program.

Conoco Plans $10½ Million Refinery Expansion Program

Additional facilities costing an estimated $10½ million will expand Continental Oil Company's Westlake Refinery at Lake Charles, La., to a daily capacity of 25,000 barrels, virtually doubling its crude oil charging capacity.

Included in the project are installation of a catalytic cracking unit and additional equipment for the production of high octane gasoline. Completion is scheduled for the early part of 1952.

Continental Oil Black Company, a new company owned jointly by Continental Oil Company and Continental Carbon Company, plans immediate construction of a $1½ million plant at Lake Charles to manufacture 25 million pounds annually of high abrasion carbon black from oil. Raw material for the new plant will be piped directly from Continental's refinery, located adjacent to the carbon black plant. Operations are expected to commence early in 1951.

British American to Expand Refinery in Saskatchewan

British American Oil Company, Ltd., was scheduled to begin a comprehensive expansion of its Moose Jaw, Saskatchewan, refinery in September. The project will increase crude handling capacity to 10,000 barrels a day from the present 6000 barrels daily level.

Plans call for construction of the first catalytic cracking unit in Saskatchewan, a coking plant, and a thermal cracking unit, as well as installation of catalytic polymerization equipment and expansion of utilities. Universal Oil Products Company is doing design engineering of the cat cracker and the poly unit.

Contract has been awarded to Process Engineers, Dallas, for construction of the major part of the program.

When completed in about 15 to 18 months, the additional facilities will enable the refinery to boost its gasoline production from 115,000 gallons a day to 227,000 gallons, and will also permit a sizable increase in the quantity of gasoline solvents and light fuels produced per barrel of crude oil.

California Subsidiaries Complete Eastern Projects

New facilities of Standard Oil Company of California subsidiaries operating in Atlantic states are nearing completion.

Projects include more than $30 million of new refinery units at Perth Amboy, N. J. scheduled to be in operation early next year. This will more than double the capacity of California Refining Company. Another subsidiary, California Oil Company, has acquired

SHOPPING FOR BLOWERS?

Look at *R-C dual-ability* with its wide selection to suit almost any job

Asking Roots-Connersville about blowers, exhausters and gas pumps has been standard practice among buyers for almost a century. That's because building such equipment is the only job we do. We're outstanding specialists in handling gas and air.

You'll gain from our wide varieties of sizes, types and capacities from 5 cfm to 100,000 cfm. We're the only manufacturers offering you the *dual-choice* between Centrifugal and Rotary Positive designs—and that *dual-ability* is important when it comes to matching the units to the jobs to be done.

So—when shopping, be sure to call on Roots-Connersville, the specialists. When you're interested in vacuum pumps, meters or inert gas generators, we're equally well fitted to fill these needs, too.

ROOTS-CONNERSVILLE BLOWER CORPORATION
510 Cresent Avenue, Connersville, Indiana

Type of Centrifugal Blower supplied to an oil company in Texas. Capacity, 13,000 cfm.

Rotary Positive Gas Pump, rated 1,500 cfm, installed in western refining company.

ROTARY

CENTRIFUGAL

ROOTS-CONNERSVILLE

BLOWER BUILDERS SINCE 1848

ONE OF THE DRESSER INDUSTRIES

The MONTH...

the New York Lubricating Oil Company's plant at Bayway, N. J., which processes base stocks into finished oils and greases.

Phillips Chemical to Build Borger Philblack O Plant

Phillips Chemical Company will soon begin construction of an additional plant for the production of Philblack O, its HAF (high abrasion furnace) carbon black. The plant will be adjacent to the present Philblack A and Philblack O plants near Borger, Texas, and completion is scheduled for late 1951.

Philblack O was first marketed in October, 1947—since then the original plant has been expanded until its annual capacity is approximately 90 million bounds. Improvements now in progress designed to promote higher yields and increase collection efficiency plus the new unit to be constructed will raise over-all capacity to approximately 160 million pounds per year. A portion of this increased capacity will be available in the first half of 1951.

Phillips Chemical will take over operations of the government-owned synthetic rubber plant near Borger. The company already operates the adjoining Plains butadiene plant, which Phillips designed and built for the government during World War II. This plant now produces more than 50,000 tons of butadiene, principal ingredient of synthetic rubber, yearly.

Because of the consolidation, a Rubber division of Phillips Chemical Company has been formed. Supervising both plants will be W. C. Hewitt, plant manager; Austin Morgan, services superintendent; G. H. Short, manufacturing superintendent; and L. M. Fairman, industrial relations superintendent.

Deep Rock Dedicates Plant In Ceremonies at Cushing

Dr. Gustav Egloff, director of research for Universal Oil Products Company, was chief speaker at the two-day dedication celebration for Deep Rock Oil Corporation's new catalytic cracking gasoline plant and other new units at Cushing, Okla.

The dedication climaxed a modernization program begun by Deep Rock at the refinery in 1949 to increase the plant's capactiy nearly 50 percent.

To Make Solvent for Paint

Shell Oil Company has completed a new plant which will produce solvents for odorless paint. Located at the company's Wood River, Ill., refinery, the new solvent unit will materially augment supply of the product, the company stated. It is being produced only in tank car quantities at present.

New Vice President Elected

W. Graham Jamison has been elected vice president of Catalytic Construction Company. He will continue as company treasurer, which position he has held since the company's formation.

Jamison was formerly assistant to the comptroller of Sun Oil Company. He is a graduate of the Wharton School of the University of Pennsylvania.

Krook

McKee

Stone & Webster Organizes Subsidiary Firm in Canada

Stone & Webster Canada Limited, a subsidiary company with offices in Toronto, Ontario, has been organized by Stone & Webster, Inc.

Alfred T. Krook, previously district manager of Stone & Webster Engineering Corporation for the Southwestern area, with headquarters in Houston, has been named president of the new company. John W. McKee of Toronto is chairman of the board of directors. Other directors are Whitney Stone and Philip B. Scott of New York, and Canadians G. Peter Campbell, William Eric Phillips, and Hartland De M. Molson, of Montreal.

Toronto offices of the new company are at 50 King Street West.

Sohio Awards Contract for Crude Distillation Plant

Arthur G. McKee Company, Cleveland, has been awarded a $5½ million contract for construction of a crude oil distillation plant at the No. 1 refinery of The Standard Oil Company (Ohio), at Cleveland.

The plant will consist of two complete units, each capable of running 22,500 barrels of crude oil per day. Improvements will also be made in existing vacuum distillation equipment.

Construction will be started early in 1951, with completion scheduled for the following November.

ECA Funds Are Allotted For European Refineries

Marshall Plan dollars, amounting to $5,220,000, will finance a little more than 10 percent of the total cost of three European refinery projects, estimated at the equivalent of $48,775,000, the Economic Cooperation Administration announced. ECA funds will pay for U. S. equipment and technical services, including engineering fees.

Industrial projects to be aided are rebuilding and modernizing an oil refinery at Dunkirk, historic French port; constructing a new refinery near Lingen, Western Germany; and installing cracking equipment for a refinery at Porto Marghera, Italy.

When the Dunkirk refinery project is completed the plant will have a capacity nearly 50 percent greater than prewar capacity. Owned by Societe Generale des Huiles de Petrole (SGHP), the refinery was virtually destroyed during the war. Reconstruction work under way includes installation of a crude topping unit which was the only equipment which survived heavy war damage to a refinery at Courchelettes, about 60 miles inland from Dunkirk. The rebuilt Dunkirk refinery will be capable of processing about 28,000 barrels of crude per day, all products to be sold in the French market.

ECA will provide $550,000 toward the modernization program of the Industria Raffinazione Olii Minerali (IROM) refinery at Porto Marghera. Immediate plans call for installation of cracking equipment, at an estimated cost of $2 million, to increase plant capacity to 4000 barrels daily.

Gewerkschaft Erdoel-Raffinerie Emsland, an organization founded jointly by the biggest crude producing companies operating in the Emsland, Germany, has started work on the erection of a new refinery near Holthausen, north of Lingen. The $8,670,000 refinery with a capacity of about 11,535 barrels daily, will be one of the largest in Germany, and is expected to go on stream in 1952. Crude will be supplied directly from the increasingly productive Emsland oil fields through a pipe line now under construction.

Louisville Refinery Adds Catalytic Cracking Unit

Work has been started on construction of a 3000-barrel-per-day Fluid catalytic cracking unit with polymerization and other auxiliary equipment, at the plant of Louisville Refining Company, Louisville, Ky. July 1, 1951 is the scheduled completion date for the $2 million project, which is being designed by Universal Oil Products Company.

The company will retain its present 2500-barrel-per-day UOP thermal cracking unit. Crude thruput of the refinery is 6000 barrels daily.

Sohio Open House at Lima Shows $30 Million Expansion

The results of the $30 million expansion and construction program at the Lima, Ohio, refinery of The Standard Oil Company (Ohio) will be inspected October 13-14. The new refinery units have been built to increase by 100 percent the capacity of the production unit.

Exhibits will explain many of the processes and will show products of the refinery. Opened for inspection will be the new cat cracker, the lube plant and the crude coker, the office and shop buildings.

Foster-Wheeler Will Build Pan-Am Southern Cracker

Pan-Am Southern Corporation has contracted for a new 7000-barrel-per-stream-day fluid catalytic cracking unit with a vapor recovery unit for its El Dorado, Ark., refinery. Engineering and construction are by Foster-Wheeler Corporation, which will complete work probably about March 1, 1951.

Pan-Am recently completed a coker and auxiliary equipment at El Dorado.

UOP Platforming Unit to Be Installed at Alma Refinery

Construction has been started on a 1500-barrel-per-day Platforming unit at Alma, Mich., refinery of Mid-West Refineries, Inc. Universal Oil Products Company expects to complete the new facilities early in 1951.

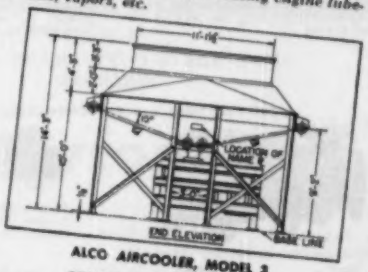
Installation of the Platforming unit

EFFICIENT PERFORMANCE

is the pay-off with ALCO AIRCOOLERS

ONE AIRCOOLER FROM THE ALCO LINE

Typical installation for cooling jacket-water. Other similar units have been used in hundreds of installations for cooling engine lube-oils, vapors, etc.



ALCO AIRCOOLER, MODEL 3

CONDENSED SPECIFICATIONS

No. radiators—Twelve 6 ft. nominal length.

Fans—11 ft. dia., 4 or 6 blade, adjustable or fixed pitch.

Drive—V-belt or Gear.

Surface External—8,160 sq. ft. Style T-5 (Water Core)
7,832 sq. ft. Style T-1 (Oil Core)

Surface Internal—1,350 sq. ft. Style T-5
1,040 sq. ft. Style T-1

Face Area—139.2 sq. ft.

Induced draft design insures peak efficiency for rugged ALCO **Aircoolers.** Air is drawn up through the cooling surfaces, then discharged at high speed from *above the cooler.* This cuts heat transfer losses, eliminates recycling hot air. Another advantage—natural draft construction permits occasional operation without the use of fans, thus paring power costs. In addition, variable pitch propellers allow a wide range of performance under all types of operating conditions.

Put the "big 5" features of ALCO **Aircoolers** to work in your plant and end cooling problems caused by an inadequate water supply, slime, or scale. You can obtain more information by sending now for the free ALCO **Aircooler** Catalog, or contacting your nearest ALCO Sales Engineer at Chicago, Cleveland, Houston, Kansas City, Los Angeles, New York or Tulsa. Plants at Dunkirk, N. Y. and Beaumont, Texas.

ONLY ALCO HAS THE BIG 5

1 Low Cost
2 Flexible Design
3 EFFICIENT PERFORMANCE
4 Easy Maintenance
5 Quick Installation

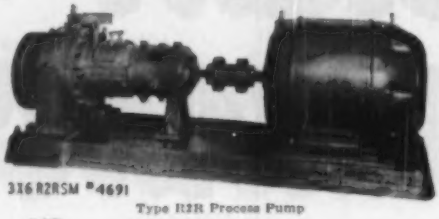
ALCO

ALCO Products Division
AMERICAN LOCOMOTIVE COMPANY

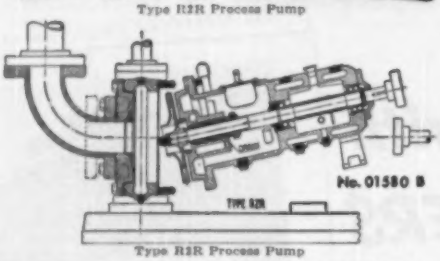
In step with tomorrow—ALCO AIRCOOLERS, Heat Exchangers, Evaporators, Feedwater Heaters, Pressure Vessels, Pipe

DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



Type R2R Process Pump



Type R2R Process Pump

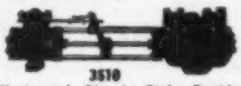
DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

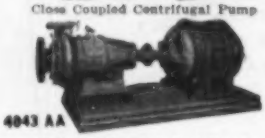
BUILDERS OF OUTSTANDING PUMPS SINCE 1869

CENTRIFUGAL and RECIPROCATING PUMPS

Close Coupled Centrifugal Pump



3510
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids



4043 AA
Pedestal Mounted Centrifugal Pump

3833
Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump

4728
Double Pedestal Bearing Centrifugal Pump

3554
Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

INDIANAPOLIS IND.

322 W TENTH ST.

Branch Offices: NEW YORK, N. Y., HOUSTON, TEXAS

Representatives in Principal Cities

The MONTH...

is part of Mid-West's program to expand refinery capacity from 4200 barrels per day to 10,000 barrels.

Plant Reopening Planned

Possible re-opening of the war-built Great Southern Corporation Thermal cracking plant at Corpus Christi, Texas, is being discussed by Pontiac Refining Company and The Chicago Corporation in a deal with the federal government.

The two firms acquired the 4000-barrel plant early this year, and had originally planned a $15 million expansion program to convert it for production of 10 million pounds of ethylene oxide and 60 million pounds of ethylene glycol annually, in addition to 5000 barrels of gasoline daily. With the advent of the Korean war, plans were modified and it is likely now that only a part of the plant will be re-opened, to produce butylene, a raw material for synthetic rubber.

Fish Builds Benzol Plant

Fish Engineering Corporation is constructing a benzol manufacturing plant for Pacific Refiners, Ltd., at a location in the Hawaiian Islands. The plant probably will be completed in December. Fish recently completed a butane asphalt refinery for the same company at Honolulu.

Refinery for England

E. E. Boudinot, construction engineer with General Petroleum Corporation since 1917, has been selected to supervise the construction of a new $30 million oil refinery to be built by Vacuum Oil Company, Ltd., in Coryton, England.

Both General Petroleum and Vacuum Oil are affiliates of Socony-Vacuum Oil Company, Inc.

The new refinery will treat Middle East crude oil primarily and will have a capacity of approximately 20,000 barrels of crude oil daily. It will specialize in the production of high grade lubricating oils.

Monsanto to Expand

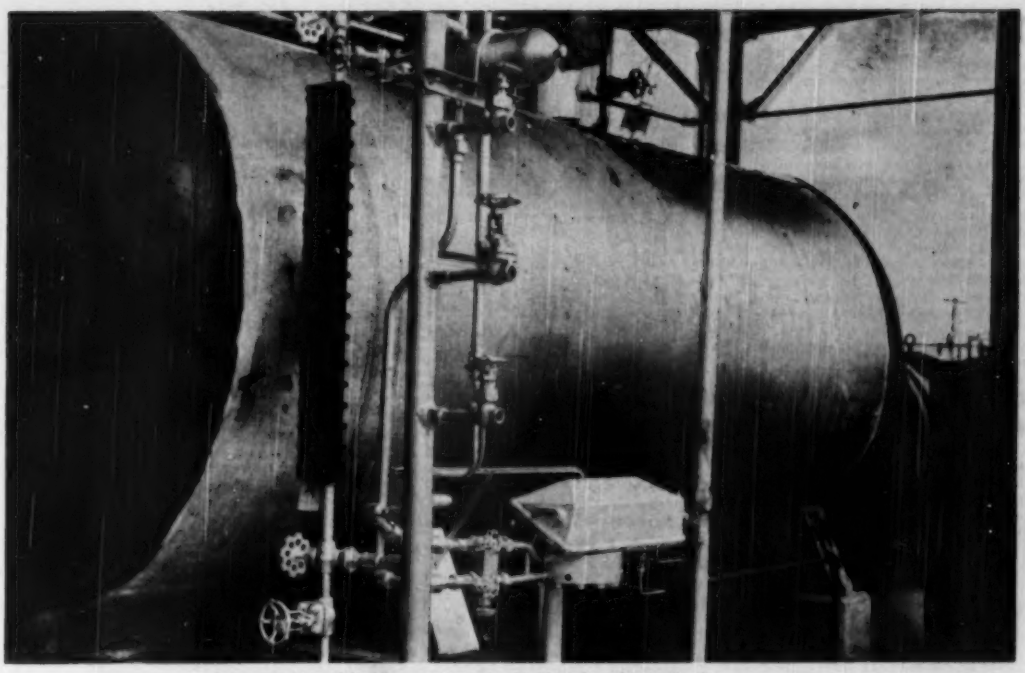
Engineering and design work has been started on Monsanto Chemical Company's Texas Division expansion program at Texas City, Texas. The plant will produce acrylonitrile and related products from processes developed at its Dayton, Ohio, and Texas City research laboratories.

Power and other utility extensions are contemplated for the increased need of the manufacturing units. It is expected that the major part of the work will be completed in 1952. Several contractors will be involved.

The new facilities will be located immediately adjacent to the present styrene plant site.

Midyear Meeting at Tulsa Planned by API Refiners

As many as nine technical sessions —including the first ever devoted to electrical equipment in refineries—will be on the program next spring when the Division of Refining of the Ameri-



Republic Transmitter measuring level in reboiler

DIFFERENT . . . in design and performance

The Republic Pneumatic Transmitter is a device for converting process variables, such as flow, level, pressure or liquid density, into air pressures. These air pressures are a direct measure of the process variables or can be used as the measuring impulse for the actuation of an automatic controller.

The force-balance method of measurement, as employed by the Republic Pneumatic Transmitter, offers many inherent advantages such as:

AMBIENT TEMPERATURE — The effect of ambient temperature variations on the accuracy of a Republic Transmitter is negligible. Since all parts are equally affected by temperature changes, force and leverage relationships are not disturbed and accuracy is unimpaired.

AIR SUPPLY PRESSURE — The effects of changes in air supply pressure is so small that it is guaranteed negligible.

LINE PRESSURE — The effect of variations in line pressure has been completely eliminated.

SENSITIVITY — Due to the negligible motions required for complete operation of all parts for full scale changes, no appreciable hysteresis results from reversal of direction of measurement change. The hysteresis loop is so small that it is undetectable by ordinary means, being less than 1/20 of 1%.

ACCURACY — The accuracy of the Republic force-balance method of measurement is higher than can be consistently secured and maintained with any other method. Transmitting pressure vs. measured force is guaranteed within ½ of 1% of meter range.

In addition to these five important features, the Republic Pneumatic Transmitter is extremely flexible in application, easy to service and of rugged construction.

If you have a flow, level, pressure or liquid density metering or control problem may we suggest that you investigate the Republic Pneumatic Transmitter? Data Book No. 1002, which contains complete details of this instrument, will be mailed to you upon request. Write for it today!

REPUBLIC FLOW METERS CO.

2240 Diversey Parkway, Chicago 47, Illinois

The MONTH...

can Petroleum Institute holds its 16th midyear meeting April 30-May 3 in Tulsa.

Analytical research, corrosion problems, disposal of refinery wastes, training of personnel, and safety are among the subjects which will have full sessions devoted to their discussion, according to W. M. Holaday, chairman of the program committee and manager of Socony-Vacuum laboratories, New York.

Motor fuels will undergo thorough discussion with at least two and possibly three sessions. One will take up the processing of stocks from crudes with high sulfur content, and the other high-vapor pressure blending stocks. Holaday said a third session on jet fuels in now under consideration.

Underwood, Smith Promoted At Sunray's Duncan Plant

R. C. (Rube) Underwood has been named superintendent and Aultman T. Smith assistant superintendent of Sunray Oil Corporation's catalytic cracking refinery at Sunray (Duncan), Okla. R. L. (Dick) Johnson is general manager of the Sunray plant.

Underwood, who joined Sunray October 27, 1947, as assistant refinery superintendent, began his refining career with Rock Island Refining Company in 1927. In 1943 he joined the Associated Refiners Inc., former operators of the plant at Duncan refinery.

Smith started in the oil business with Cosden Oil Corporation in 1933, joined the Associated Refiners, Inc., in 1943 and started with Sunray in 1947.

CNGA Past Presidents Slated to Conduct Forums

Five forums, each led by a past president, will feature the first day's sessions of the fall meeting of the California Natural Gasoline Association, scheduled to meet November 9 and 10 at the Ambassador Hotel, Los Angeles.

Topics for these discussions and the leader of each are as follows:

"The Efficient Operation and Maintenance of Plant Equipment," conducted by J. B. Taylor, manager gas department, Signal Oil & Gas Company.

"The Application of Chemical and Process Engineering Principles to the Efficient Design and Operation of Natural Gas Processing Plants," by C. D. Gard, process engineer, Union Oil Company.

"The Role of the Chemist and Laboratory in Efficient Natural Gas Operations," by W. W. Robinson, Jr., chief chemist, Technical service and research laboratory, Pacific Coast Division, The Texas Company.

"The Efficient Mechanical Design of Natural Gas Processing and Compression Plants and Natural Gas Gathering and Distributing Systems," by M. W. Kibre, manager, natural gas and gasoline dept., General Petroleum Corporation.

"The Efficient Management of Natural Gas and Natural Gasoline Operations," leader not announced.

The second day's activities will be featured by papers presented during the day by men who have been actively engaged in the work of the Association for the past 25 years. These will point out the functions of the natural gas and gasoline departments in the operations of an oil company as well as the significance of natural gas and gasoline operations in California's economy.

M. L. Arnold, Richfield Oil Corporation, is general chairman.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1949:									
January 29	5,493	5,490	255,450	17,321	114,677	7,547	63,142	8,178	63,333
February 26	5,401	5,412	261,965	17,621	124,382	7,430	54,008	8,225	59,348
March 26	5,188	5,353	268,506	17,417	128,087	6,147	48,721	8,305	58,702
April 30	4,980	5,273	271,355	17,969	124,787	6,661	49,959	8,185	60,174
May 28	4,951	5,297	275,190	18,324	120,661	5,943	55,971	8,144	63,758
June 25	4,944	5,322	274,114	18,462	115,716	5,148	63,040	7,856	66,148
July 30	4,731	5,187	271,999	18,056	109,964	6,293	70,767	7,205	67,166
August 27	4,769	5,215	266,455	18,150	106,280	6,491	74,718	7,587	66,294
September 24	4,923	5,377	259,180	18,182	103,202	6,585	81,414	7,619	66,145
October 29	5,075	5,509	252,060	19,002	103,915	7,016	90,358	7,784	66,459
November 26	5,192	5,331	256,409	18,204	104,917	6,971	91,795	8,104	67,057
December 24	4,955	5,482	256,330	18,045	110,164	7,235	78,663	8,049	61,847
1950:									
January 28	4,885	5,470	248,411	18,265	124,270	7,202	66,257	8,249	57,026
February 25	5,000	5,277	245,586	17,703	133,886	6,980	56,050	7,955	48,663
March 25	4,848	5,400	244,227	17,520	135,406	6,570	40,477	8,171	42,546
April 29	5,014	5,314	244,744	18,038	128,656	6,531	36,686	7,772	39,260
May 27	5,118	5,591	240,842	18,704	122,787	7,201	40,607	7,421	39,306
June 24	5,355	5,636	240,762	19,626	115,086	6,966	50,580	7,461	41,291
July 29	5,522	5,870	240,236	19,981	109,076	7,266	61,437	7,870	42,253
August 26	5,609	6,197	236,974	20,263	105,793	7,550	65,841	8,543	41,597
September 30	5,905	6,051	*239,641	19,624	104,383	8,460	76,734	8,306	42,330

* September 23, Stocks.

Socony-Vacuum Appoints Four Refining Executives

Frank C. Fahnestock, technical advisor since 1948 to the chief engineer, refinery engineering division, Socony-Vacuum Oil Company, Inc., has been appointed coordinator of foreign refining in the company's manufacturing department.

Fahnestock

R. R. Jackson, manager of Socony-Vacuum's Paulsboro, N. J., refinery, and S. D. Dalton, manager of the refinery engineering division, have been appointed to the company's manufacturing committee. Jackson is succeeded at Paulsboro by E. L. Sinclair, assistant manager. Dalton continues as manager also of the Refinery Engineering division.

Fahnestock, graduate of Massachusetts Institute of Technology in 1931, started with Socony-Vacuum as a student engineer and held various operating jobs at the Paulsboro, N. J., refinery until 1939, when he was transferred to Refinery Engineering. He was ECA consultant on oil for Western Germany from March to May, 1950.

A graduate of the University of Texas, Jackson started in 1923 at Beaumont, Texas, in the refinery of Magnolia Petroleum Company, an affiliate of Socony-Vacuum. Prior to becoming manager of the Paulsboro refinery in 1946, he was superintendent of the Beaumont refinery.

Dalto, who was graduated from Stanford University in 1930 and from MIT in 1932, started in 1933 with General Petroleum Corporation and was transferred to Socony-Vacuum in 1940.

Sinclair is a graduate of the University of Michigan and started with Socony-Vacuum 12 years ago.

Vice Presidents Elected

Elected vice presidents of Sinclair Refining Company and announced last month are Roy J. Tibbets to be vice president in charge of all pipe lines and a member of the board of directors; William H. Mooris to be vice president and general manager of crude pipe line operations; C. F. McGoughran vice president and general sales manager; and H. H. Fuller vice president to direct all wholesale activities of the company.

Frey Named by ACS for Petroleum Division Post

Frederick E. Frey, assistant director of research for Phillips Petroleum Company, has been named chairman-elect for the petroleum division of the American Chemical Society. He will serve as chairman-elect until September, 1951, when he will succeed B. H. Shoemaker of Standard Oil Company (Indiana), present chairman.

Frey, a graduate of Ohio State University and the College of Wooster, Wooster, Ohio, worked for the Bureau of Mines before joining Phillips in 1927 as a research chemist.

Recognized as one of the outstanding petroleum chemists in the country, Frey has made many substantial and pioneering contributions in a number of fields of hydrocarbon chemistry. In 1947, Frey was selected by the Chicago section of the American Chemical Society as one of the ten outstanding petroleum chemists in the United States.

New McKee Representative Appointed for Southwest

R. P. Mase has been appointed Southwest sales representative of Arthur G. McKee and Company's petroleum refining division. Mase, who will have his office in Tulsa, has been an active petroleum engineer for the past 25 years, and for the past ten years has been chief engineer of Jones & Laughlin Supply Company.

Military Policy Revised

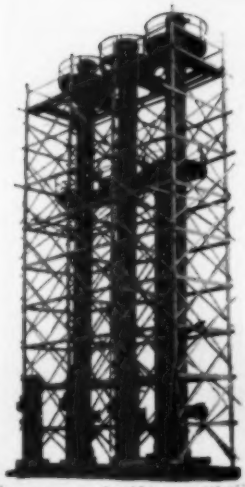
Continental Oil Company has revised its military leave policy for employes entering the armed forces to include a supplemental allowance for dependents, continuation of group life insurance and retirement plan credits.

NUMBER 2 OF A SERIES

Our installation time was only 1½ manhours for each 2-foot tray

and the Koch Kaskade fractionating trays in our new gasoline plant are operating fine!

PEPPERS REFINING COMPANY



SATISFIED by the operation of Koch Kaskade trays in another of their gasoline plants, Peppers naturally specified them in all the towers of their new gasoline plant at Britton, Oklahoma. These towers include an absorber, stripper, deethanizer, depropanizer and a debutanizer.

A LARGE number of Koch Kaskade tray installations are repeat orders from satisfied customers. It will pay you to investigate the economy and operating efficiency of Koch Kaskade fractionating trays. Write us today, no obligation.

THE KOCH ENGINEERING COMPANY, INC.

Special technique assures quality of Kellogg "knock-down" vessels

ONE of the frequent causes of high cost in the field-construction of large refinery vessels does not really start in the field at all. Actually it occurs in the shop-fabrication of these "knocked-down" vessels.

Mis-alignment is the field man's bogey . . . mis-alignment, not only between segments of any one course of a vessel but also between the different courses themselves.

To preclude the possibility of saddling any constructor's field crews with the costly field correction of "misfits," Kellogg shops follow a special routine developed from both *shop and field* experience.

In effect Kellogg completely "builds" even the largest vessels right in the shop. Beyond matching individual segments to master templates, each successive course of every vessel is superimposed on the previously assembled course. "Knocked-down" vessels built in this manner for the field can't help but fit.

Such accuracy in fabrication has brought wide recognition of Kellogg quality in all types of vessels. It gives assurance of exact tray positioning and leveling and of close tolerances in nozzle positioning. It's another reason why Kellogg vessels—completely shop-built or shop built in "Knock-down" form—achieve high operating efficiencies and low maintenance records.

Illustrated—Alloy clad 25' diameter reactor being "Knock-down" fabricated in Kellogg shops.

To master temperature and pressure use

M. W. KELLOGG

piping and process equipment

The M. W. Kellogg Company (Subsidiary of Pullman Incorporated)—Offices in New York, Jersey City, Buffalo, Los Angeles, Tulsa, Houston, Toronto, London and Paris

SCIENCE and TECHNOLOGY Abstracts

Prepared by
DR. E. H. LESLIE and DR. H. B. COATS
The Leslie Laboratories
Traver Road, Ann Arbor, Mich.

Fundamental Physical and Chemical Data

Vapor Pressures of Normal Saturated Hydrocarbons. GEORGE THODOS. *Ind. Eng. Chem.*, **42** (1950), pp. 1514-26.

The author made a critical survey of all vapor pressure data available in the literature and selected the most reliable values as a foundation for vapor pressure studies between the triple and critical points for the normal saturated aliphatic hydrocarbons up to and including n-Dodecane. To represent the vapor pressure data accurately requires separate treatments of the inherently different high and low vapor pressure regions. The point at which these regions merge is called the divergence point. A generalized equation is given that represents accurately all vapor pressure data below this divergence point. By addition of a graphical residual applicable above the divergence point, the generalized equation can be used over the entire range of vapor pressures. This graphical residual or increment can be expressed mathematically. Constants in the equations have been uniquely determined for each hydrocarbon and are expressed as functions of the normal boiling point. Vapor pressures calculated for each of the hydrocarbons by the author's method give an average absolute error of 0.2 percent. This indicates a marked improvement in accuracy over past vapor pressure equations proposed for these compounds.

Thermal Conductivity of Gas Mixtures. ALEXANDER L. LINDSAY and LEROY A. BROMLEY. *Ind. Eng. Chem.*, **42** (1950), pp. 1508-11.

An equation was developed for the thermal conductivity of gaseous mixtures that require only data on pure component conductivity, heat capacity or viscosity, boiling points, and molecular weights. The history of the general subject is reviewed with comments on other equations that have been used. The conductivities of 85 different compositions of 16 gas pairs for which experimental data are available in the literature were calculated. The average deviation of the calculated experimental points is 1.9 percent. Results of these calculations are presented in detail in tabular form.

Bond Hybridization in the Nontetrahedral Carbon Atom. The Heats of Combustion of Spiropentane and Methylcyclobutane. GEORGE L. HUMPHREY and RALPH SPITZER. *J. Chem. Phys.*, **18** (1950), p. 902.

The heats of combustion/mole of liquid at 25° C. and 1 atm. pressure of spiropentane and methylcyclobutane are 778.7 and 801.1 kcal. respectively. Calculated values obtained by assuming tetrahedral bonds and including a torsional strain energy of 2 kcal. per opposed CH_2 group, are 785.6 and 806.3 kcal. mole, resp.

Heats of Polymerization. A Summary of Published Values and Their Relation to Structure. DONALD E. ROBERTS. *J. Research Natl. Bur. Standards*, **44** (1950), pp. 221-32 (Research Paper No. 2-73).

Forty-two substituted vinyl compounds were studied, including vinyl alkyls, vinyl aryls, vinyl acids and esters, dienes, and copolymers. The heats of polymerization to hypothetical polymers that have no steric hindrance were calculated using energy effects from published values of heats of formation of the hydrocarbons. Ethylene has the highest, and alpha-methylstyrene the lowest, heat of polymerization. The heats of isobutene and methacrylates are low. Steric interference can be caused by disubstitution on the same vinyl carbon or by the presence of large branched substituents. Steric hindrance may prevent polymerization above the dimer.

The Solubility of Hydrogen Bromide in Normal Paraffin Hydrocarbons. EDWARD R. BOEDEKER and CECIL C. LYNCH. *Jour. Am. Chem. Soc.*, **72** (1950), pp. 3234-6.

The purpose of the work was to obtain solubility data for several hydrogen bromide-n-paraffin hydrocarbon systems at several temperatures. Accordingly, the solubility of hydrogen bromide in n-hexane, n-octane and n-decane was measured at 25, 35 and 45° C. The heat of solution of hydrogen bromide in each of these solvents was calculated. The solubility of hydrogen bromide in n-paraffin solvents of varying carbon content can be predicted from the experimental data. At any temperature, the value of Henry's law constant approaches a limiting value as the number of carbon atoms in the n-paraffin solvent is increased.

These abstracts from the current literature of science and technology (not including trade journals easily available) were prepared by Drs. Leslie and Coats of The Leslie Laboratories, Traver Road, Ann Arbor, Mich., which will supply, at cost, photostatic copies of original articles. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, also may be had by arrangement with the laboratories.

Dicyclic Hydrocarbons. I. 2-Alkylbiphenyls. IRVING A. GOODMAN and PAUL H. WISE. *Jour. Am. Chem. Soc.*, **72** (1950), pp. 3076-9.

As part of a program being conducted at the Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics, which program involves the investigation of possible components of aviation fuel, a series of five 2-substituted alykylbiphenyls was synthesized and purified. The preparation and physical properties of five pure 2-substituted alkylbiphenyls are given. 2-Butylbiphenyl was shown to exist in two distinct crystalline modifications.

The Dissociation Energies of the C-H Bond in Propylene and the C-C Bond in 1-Butene. M. SZWARC and A. H. SHEON, University of Manchester, England. *J. Chem. Phys.*, **18** (1950), pp. 237-8.

Gaseous 1-butene was cracked in a stream of toluene at temperatures between 935 and 1046° K. at a toluene pressure of 4 to 16 mm. of Hg and a molar ratio of toluene to butene of 30-1. The rate of formation of CH_4 was used as a measure of the decomposition rate. Hydrogen was produced along with butadiene. The dissociation energy of the C-C bond was determined, and values for C-H bond calculated.

Chemical Composition and Reactions

Analysis of East Texas Virgin Naphtha Fractions Boiling Up to 270° F. MARY FRANCIS BELL. *Analytical Chem.*, **22** (1950), pp. 1005-14.

The first part of the paper describes infrared procedures by means of which the paraffin-naphthene portion of virgin naphthas can be analyzed for all components boiling up to 270° F. The analytical procedure distinguishes between all isomers, including cis- and trans-alkyl cyclopentanes and alkylcyclohexanes, with one exception. The second part of the paper presents the results of the quantitative analysis of the paraffin-naphthene portions of an East Texas naphtha for all compounds boiling up to 215° F., and of an East Texas heavy naphtha for compounds boiling up to 270° F. Quantitative data on 3 n-paraffins, 34 isoparaffins, 22 cyclopentane homologs, and 10 cyclohexane homologs are given. The work represents an extension of approximately 30° F. above the highest boiling point for which the quantitative analysis of the paraffins and naphthenes in crude oil has been reported previously.

low-cost process heat

dependable low-speed power

GET BOTH with G-E

If your plant uses process steam, you may be able to improve over-all heat balance by driving low-speed equipment with General Electric geared turbines. Mechanical drive turbines act as reducing valves to drop boiler steam pressures down to utilization temperatures for process requirements. With turbines skimming off only a small portion of the steam's heat, mechanical power for driving fans, blowers, pumps and other low-speed apparatus is almost free.

Standard Type DP and DR turbines, combined with General Electric precision-type gears, are ideal for many such applications.

PRECISION GEARING

General Electric balanced-thrust gears are specifically designed for use with turbine drives. Smoothness and quietness of operation are the result of maintaining tooth contours and spacing to a high degree of accuracy.

Positive lubrication assures long life. Oil is delivered to the bearings from a gear-type pump driven by the pinion shaft. The gear mesh is spray-lubricated.

To meet a variety of application requirements, these gears are available in ratios from 1.5 to 10.3.

PRECISION GOVERNING

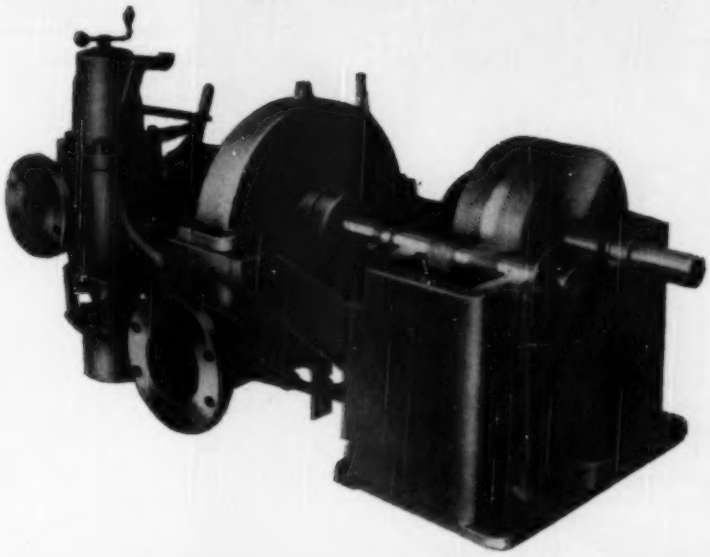
General Electric Type DP and DR turbines include extra features at no extra cost. The DP's hydraulic governing system provides a speed range of 30 per cent with 6 per cent regulation. The DR's oil-relayed governor offers speed ranges up to 5 to 1 with accuracy of ¼ of 1 per cent. Each turbine has its easily operated trip-throttle valve and governing valve combined in one compact unit. Rugged construction from quality materials makes these standard turbines outstanding for reliability and efficiency.

ONE INTEGRAL UNIT

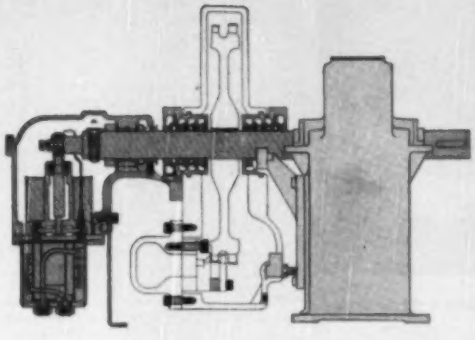
General Electric close-coupled turbine-gear sets have one common turbine and pinion shaft, with the turbine and gear casings solidly connected by a sturdy fabricated bracket. This construction results in a compact unit, does not require high-speed coupling.

Many standard parts are interchangeable with other turbine and turbine-gear drives.

Your nearby General Electric sales office will supply you with full details about mechanical-drive turbine-gear sets. Or, if you prefer, write for free copies of illustrated bulletins on these drives. The DP and DR turbines are described in bulletins GEA-4955 and GEA-5193. Bulletin GEA-5152 contains information about gears. Learn how installing these precision drives in your plant can save you money. Apparatus Department, General Electric Company, Schenectady 5, N. Y.



TURBINE-GEAR DRIVES

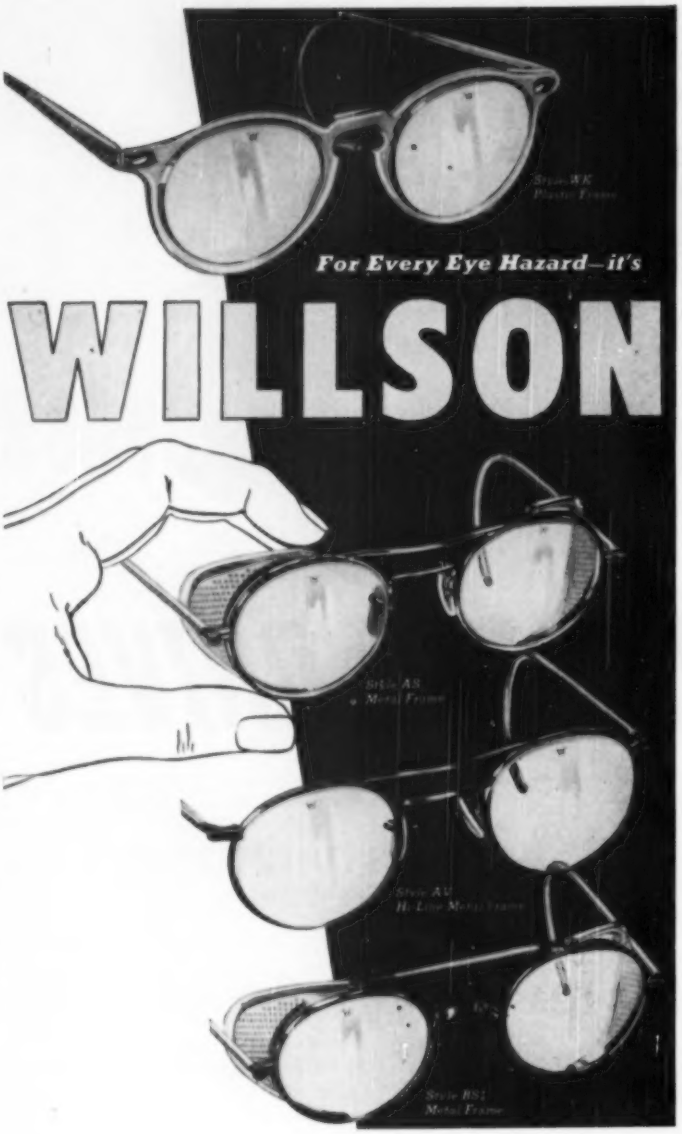


HERE'S WHAT STANDARDIZATION PROVIDES FOR YOU

This diagram shows how a standard DP turbine is close-coupled to a low-speed gear using an integral turbine and pinion shaft. All shaded turbine parts are interchangeable on all sizes of DP turbines. Thus, it is easy to stock spares, and maintenance costs are reduced. All individual turbine models and gear sets have standard shaft heights for easy installation or re-location in your plant. In addition, standardization cuts manufacturing expense, and the savings are passed on to you in the form of extra features usually found only on "special" turbine-gear drives.

GENERAL ELECTRIC

152-43



WILLSON*
Dependable Products Since 1870
*T.M. Reg. U.S. Pat. Off.

Protection • Comfort • Appearance

. . . only the most complete line of safety spectacles with Super-Tough* lenses gives you *all three* in metal or plastic frames. You'll find WILLSON safety spectacles an ideal combination of strength, comfort and good looks. And you need *all three* to get full cooperation from workers who must wear eye protection. See our new catalog for complete information. Get it from our nearest distributor, or write direct to WILLSON PRODUCTS, INC., 202 Washington St., Reading, Pennsylvania.

Science and Technology

The Nitrogen Compounds in Petroleum Distillates. XXVII. Isolation and Identification of 2,3-Dimethyl-6-isopropyl-pyridine from California Petroleum. H. L. LOCHTE, A. D. BARTON, STILES M. ROBERTS and J. R. BAILEY. *Jour. Am. Chem. Soc.*, **72** (1950), pp. 3007-9.

The nitrogen bases studied were recovered from the hydrochlorides found in the chloroform layers after the extraction of an aqueous solution of hydrochlorides of the bases boiling in the range 175-235° C. The purification process used is described in some detail as well as the methods used in establishing the structure of the compounds. A $C_{10}H_{15}N$ base was isolated which was shown to be *2,3*-dimethyl-6-isopropyl-pyridine.

Polymerization of Isobutene by BF_3—The Polymerization of Isobutene by Boron Trifluoride. A. G. EVANS and G. W. MEADOWS, University of Manchester. *Trans. Faraday Soc.*, **46** (1950), pp. 327-31.

It was found that a co-catalyst is required for the low-temperature high molecular weight polymerization of isobutene by boron trifluoride (BF_3). When these materials were highly purified and condensed together at —80° C. for several hours no polymerization occurred. A minute quantity of co-catalyst causes instantaneous polymerization of isobutene to solid polymer at low temperature. A possible mechanism and causes of the reaction are discussed.

Isomerization Accompanying Alkylation. VI. Reaction of Isobutylene and 2-Butene with Benzene. HERMAN PINES, J. L. LAZERTE and V. N. IPATIEFF. *Jour. Am. Chem. Soc.*, **72** (1950), pp. 2850-3.

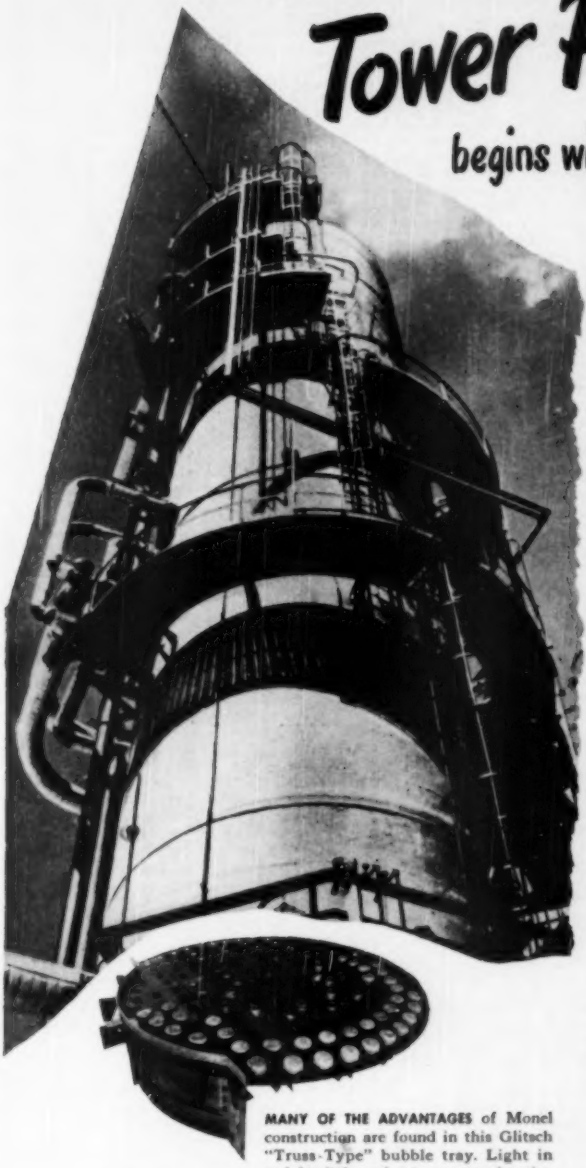
Catalytic alkylation of Benzene with butylenes at elevated temperatures and pressures has not been studied heretofore with the purpose of establishing the structure of the compounds produced. The purpose of the work reported was to determine whether such an alkylation is accompanied by a skeletal isomerization of the alkyl group. Catalytic reaction of *2*-butene and isobutylene with benzene was studied. It was found that silicophosphoric acid and alumina-zinc chloride catalysts cause skeletal isomerization to accompany alkylation. The dealkylation of di-t-butylbenzene and di-s-butylbene, respectively, in the presence of benzene and catalysts yield a mixture of t- and s-butylbenzene. In the presence of silicophosphoric acid and zinc chloride-alumina catalyst s-butylbenzene isomerizes partly to t-butylbenzene and t-butylbenzene to s-butylbenzene.

Reactions Between SO_2 and n-Butane. The Kinetics of the Photochemical Gas-Phase Reactions Between Sulfur Dioxide and n-Butane and 1-Butene Respectively. F. S. DAINTON and K. J. IVIN. *Trans. Faraday Soc.*, **46** (1950), pp. 382-94.

The results of a detailed investigation of the reaction of n-butane and 1-butene with sulfur dioxide are reported. Use was made of ultraviolet light in the wave length range 2400-3340 A. and at temperatures between 15 and 100° C. The excitation of the sulfur dioxide molecules is followed by a competitive process, including addition to the hydrocarbon, quenching by the hydrocarbon

In designing for all types of crudes...

Tower Protection begins with Monel!



MANY OF THE ADVANTAGES of Monel construction are found in this Glitsch "Truss-Type" bubble tray. Light in weight, it is easier to erect and maintain. Monel's ductility eliminates breakage during installation and cleaning... Smooth, corrosion-resistant Monel surfaces increase tower efficiency, reduce coking hazards. And Monel caps and trays, if distorted by explosion, can be readily straightened and restored to service... *This photo used through courtesy of the fabricator, Fritz W. Glitsch & Sons, Dallas, Tex.*

Design engineers seldom know, these days, what the next crude will be like.

Today sweet—tomorrow sour. Or maybe a mixture of both. That's why top sections of fractionating towers need *plenty* of protection against corrosion.

And they get this protection from MONEL*. That has been proved time and again in every refining center.

Just recently, for example, The M. W. Kellogg Company, refinery and chemical engineers of Jersey City, New Jersey, designed a large refinery for charging a sour crude containing in the neighborhood of 2% sulfur. Kellogg knew from past experience that most commercial metals used in the top sections of the fractionating vessels would pit due to corrosive action by sulfur and salt compounds in condensed water vapor.

Consequently Kellogg engineers recommended Monel-lined nozzles for refluxing in top tower sections for temperatures of 400°F. or below. Monel does not pit under these conditions, and Kellogg knew it would display satisfactory resistance to predicted corrosion in the upper tower sections where temperatures below the dew-point are encountered.

Monel, as a matter of fact, is highly resistant to sulfur attack at temperatures up to 500° F. It resists corrosion by sulfuric acid, dilute hydrochloric acid, brines, sour crudes, caustics and chlorinated solvents. Its high strength and low corrosion rate make possible the use of thin, lightweight sections that save you money in both material cost and tower design.

Before you choose a metal for top tower sections, be sure to investigate the advantages of using Monel. Write us for information and technical data now, so you'll have all the facts on hand when you need them.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y. *Reg. U. S. Pat. Off.

ENGLEN OF SERVICE INCO TRADE MARK

MONEL...for minimum maintenance and replacement

Science and Technology

and internal deactivation. Possible reaction mechanisms are discussed for the uninhibited n-butane reaction, the n-butane reaction retarded by 1-butene or butadiene, and for the 1-butene reaction.

The Kinetics of the Reaction of Aluminum Borohydride Vapor with Olefins. RICHARD S. ERIKAW and ROBERT N. PEASE. *Jour. Am. Chem. Soc.*, **72** (1950), pp. 3237-41.

The kinetics of the reaction between aluminum borohydride and ethylene, propylene and butene-1 were studied. The products of the reaction of aluminum borohydride with ethylene were isolated. The reactions were found to be of the first order with respect to aluminum borohydride pressure and to be independent of the olefin concentration. The activation energy was determined and a reaction mechanism is proposed. Boron alkyls are among the reaction products. Aluminum borohydride vapor and an excess of ethylene at 140° C. react to yield boron triethyl and an ethyl-aluminum compound.

Sulfinic Acids From SO_2 and Hydrocarbons. The Photochemical Formation of Sulfinic Acids from Sulfur Dioxide and Hydrocarbons. F. S. DAINTON and K. J. IVIN. *Trans. Faraday Soc.*, **46** (1950), pp. 374-81.

The only reactions that have been reported between sulfur dioxide and hydrocarbons are those in which unsaturated hydrocarbons react to form a polysulfone, and with the conjugated dienes, a cyclic monosulfone. The authors found that both paraffins and olefins combine readily with sulfur dioxide in the gas phase in the presence of ultraviolet light to yield sulfinic acids. The paraffins also give sulfinic acids in the liquid phase whereas the olefins give polysulfones. Tertiary carbon atoms are attacked more readily than secondary, and secondary carbon atoms more readily than primary. The olefins are less reactive than the paraffins.

Manufacture: Processes and Plant

Industrial Fractionating Tower Packing. R. C. SCOFIELD. *Chem. Eng. Progress*, **46** (1950), pp. 405-14.

A tower packing was made of elements comprising a number of layers of metal lath compacted and then bent into a V-shape. Trays thus formed were placed with the apexes of one layer touching the apexes of the layers above and below. This type of packing was found to have higher capacity and improved "HETP" when compared with conventional bubble-cap towers. Pressure range studied covered vacuum at 180 mm. Hg abs., atmospheric pressure and elevated pressure of 160 psia. in a small test tower. Towers up to 4 feet in diameter were studied. At atmospheric pressure, substitution of the packing in an existing 36 tray bubble tower with trays on 1.5-foot spacing, resulted in a tower giving performance equivalent to 100 bubble-cap trays. It is stated that savings up to a sixfold reduction in tower size can be realized in the principal cost items such as vessels, structural steel, foundations, insulation, transportation, and erection charges.

Pressure Drop Through Porous Media. Part IV—New Data and Revised Correlation. L. E. BROWNELL, H. S. DOMBROWSKI, and C. A. DICKEY. *Chem. Eng. Progress*, **46** (1950), pp. 415-22.

The work reported is a continuation of previous work on the subject. New data on flow through porous media are given for packed beds covering a range from completely streamline flow to highly turbulent flow, and a range of porosity from 40 to 94 percent. Pressure drops observed experimentally are compared with those predicted by various correlations. The method of correlation previously given has been revised.

Solid-Fluid Heat Exchange in Moving Beds. WILLIAM D. MUNRO and NEAL R. AMUNDSON. *Ind. Eng. Chem.*, **42** (1950), pp. 1481-8.

The authors present a solution of the problem of heat exchange between solid and fluid for parallel or countercurrent exchangers. A solid is assumed to comprise uniform spheres. The resistance to heat transfer by conduction in the spheres is given consideration. Heat generation inside the spheres can occur either at a constant rate or as a linear function of temperature. Theoretical equations were solved by means of the Laplace transformation. An example of the special application of the method is in the use of the equations in catalytic reactor design. Numerical examples are included in which the results of the authors' method are compared with those of approximate treatments. It was found that the approximate treatments predict exchangers whose transfer area is too small.

Bower Characteristics of Mixing Impellers, Part I. J. H. RUSHTON, E. W. COSTICH, and H. J. EVERETT. *Chem. Eng. Progress*, **46** (1950), pp. 395-404.

The purpose of the work was to establish the characteristics of various types of impellers used commercially for agitation and mixing operations in liquid systems. These were studied under conditions existing in the laboratory and in large-scale operations. Correlations of the important variables are given in the form of dimensionless groups, characteristic plots, and genera equations. The properties of impellers, tanks and fluids were studied over wide ranges of power, size, and physical properties. The types of mixing equipment studied included marine-type three-blade propellers; paddles; flat, curved and arrow-head blade turbines; fan turbine; and a curved-blade turbine with shrouding. Sizes of propellers used range from 3 to 20 inches in diameter and turbines 3 to 48 inches in diameter. Tanks included vertical, cylindrical and flat bottomed, and varied from 8.5 to 96 inches in diameter. Some tanks were used without baffles and others with four vertical wall baffles extending 17.7 percent of tank diameter. Fluid viscosities covered the range 1 to 40,000 cp., and power measurements were made over the range from 0.001 to 8 hp. Correlations in terms of Reynolds number extend from 1 to 1,000,000.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

Aluminum triethyl
2-Carboxy-5-n-butyl pyridine
Tetramethylhydrazine
1-(p-Methoxyphenyl)-2-epoxypropane
N,N-Dimethylthioacetamide
2-Amino-5-nitrothiazole
2-n-Butyl hydroquinone
5-Nitrofurfural
o-Isobutyl phenol
2-Ethyl pentanol-1
Phenyl acetyl urea
2,6-Dichlorophenol
2-Phenylcyclohexanone
1,1,2-Triodopropane
Hexane-2,4-dithiol
2,6-Dimethyl heptanetriol-2,4,6
2,5-Difluoro toluene

Alfin Catalysts and the Polymerization of Butadiene. AVERY A. MORTON. *Ind. Eng. Chem.*, **42** (1950), pp. 1488-96.

Alfin catalysts are special combinations of sodium salts that cause rapid catalytic polymerization of butabiene to compounds of unusually high molecular weight. The reactions brought about by organo-sodium compounds are peculiar, in that they involve multiple steps, or show a tendency to undergo multiple reactions. These reagents are insoluble aggregates of ions, the behavior of which is affected by the ions in the aggregate. The polymerizations brought about through these reagents show no similarity to those effected with the conventional sodium process for polymerizing butadiene. Theory of the reactions, including the polymerizations caused by organo-sodium compounds, is discussed. The difficulty in the practical use of the Alfin polymers lies in its toughness. It will not soften on a mill as does natural rubber. However, progress has been made in producing products that can be milled and that have other interesting and important properties.

How Ethyl Makes Antiknock Compounds. JOHN H. SCHAEFER. *Chem. Eng., Chem.*, **42** (1950), p. 1607.

The plant of Ethyl Corporation at Baton Rouge, La., and the operations conducted in it are described. Products include hydrochloric acid, hydrogen chloride gas, byproduct salt cake, benzene hexachloride, ethylene, ethylene dichloride, chlorine, sodium, ethyl chloride, lead-sodium alloy, tetraethyl lead, and finally "Ethyl" antiknock compound. More than half of the nation's supply of ethyl chloride is made here. The process of manufacturing ethyl fluid is briefly outlined, as well as the steps in the production of each of the intermediate compounds. Final blending to make "Ethyl" fluid is described.

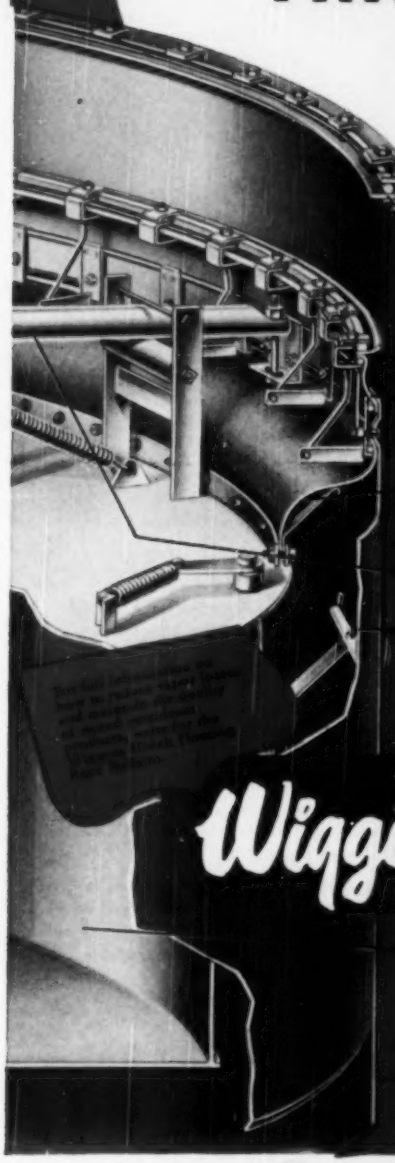
Liquid Fuel From Coal. First Year of Operation of Coal Hydrogenation Demonstration Plant at Louisiana, Mo. L. L. HIRST and C. C. CHAFFEE. *Ind. Eng. Chem.*, **42** (1950), p. 1607.

The authors describe experiences in operating a Bureau of Mines hydrogenation demonstration plant at Louisiana, Mo. Various difficulties encountered are briefly described. In one long run using Wyoming Rock Springs coal an average of 48 tons of coal per day were proc-

No other floating roof gives you . . .

TRIPLE SEAL

protection



The improved and never surpassed

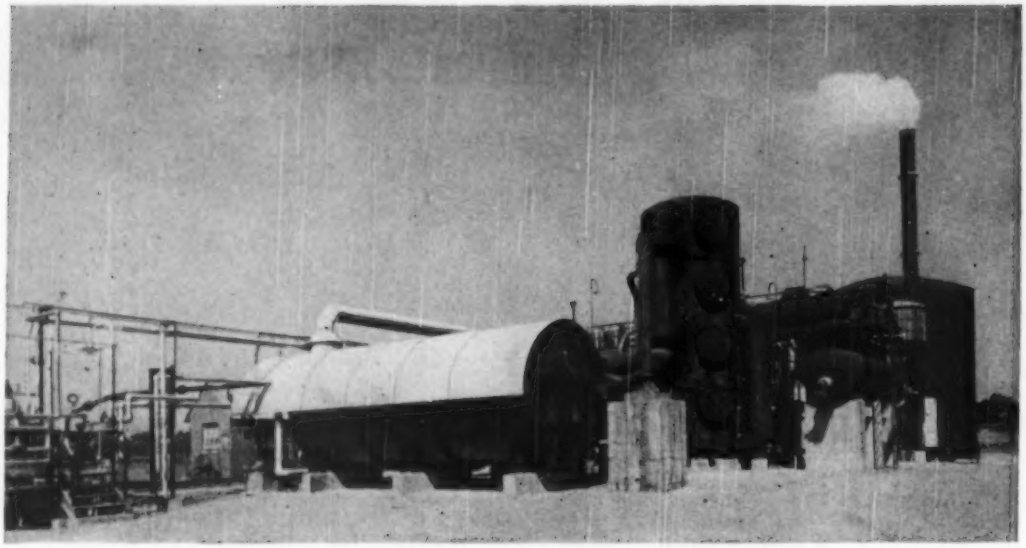
Wiggins Floating Roofs

GENERAL AMERICAN

First New-Type

CHEMICO SULFURIC ACID PLANT

now in operation



The first plant, utilizing Chemico's new process for making sulfuric acid from sulfur, is now in successful operation at the Hamilton, Ohio works of the American Cyanamid Company. This new unit—rated at 50 tons per day can deliver sulfuric acid of any strength up to 95% H_2SO_4.

This new-type Chemico plant is basically simpler than conventional type contact sulfuric acid plants. The new process differs in these basic ways.

- It converts SO_2 to SO_3 in a highly efficient quench converter. This eliminates heat exchangers . . . assures higher yield from raw sulfur . . . virtually eliminates contamination due to unconverted SO_2.
- From the converter, the SO_2 gas mixture passes through a multiple dip-pipe absorption system, which operates by gravity flow. There is no need to distribute acid over packed absorbing towers.
- Water evaporation from absorber acid solutions removes heat of absorption and the sensible heat of hot gases. Only a small amount of cooling water is required for the product acid before storage.
- A built-in Pease-Anthony Venturi Scrubber insures mist elimination in the exhaust stack.
- Seven major items of equipment — usually found in present-type contact acid plants — have been eliminated: drying tower, gas filter, heat exchanger, SO_3 cooler, acid coolers, acid circulating and transfer pumps and diluting equipment.

THE RESULTS — The new-type plant is much smaller. It can be economically built and operated. Investment cost is lower per ton of capacity. Startup, shutdown and operation are easier.

CC 907

CHEMICAL CONSTRUCTION CORPORATION

A UNIT OF AMERICAN CYANAMID COMPANY

488 MADISON AVENUE, NEW YORK 22, NEW YORK

EUROPEAN TECHNICAL REPRESENTATIVE

CYANAMID PRODUCTS, LTD., LONDON W.C.2, ENGLAND • CABLES: CHEMICONST, NEW YORK

Chemico plants are profitable investments

essed at an average conversion temperature of 867° F., under 7400 psi. total pressure and 6360 psi. hydrogen partial pressure. Liquefaction was always over 90 percent. Stannous oxalate, in the proportion of 0.15 percent of dry coal, was used as catalyst, but will in the future be replaced by an iron catalyst.

Desulfurization of Coal During Carbonization. High-Sulfur Indian Coal. J. K. Ghosh and R. E. Brewer. *Ind. Eng. Chem.*, **42** (1950), pp. 1550-8.

Earlier work by the authors showed that certain American coals, rich in pyritic sulfur, could be desulfurized by treatment at 800° C. in the presence of ammonia gas. A study of this procedure has been applied to low ash, good-coking, but abnormally high-sulfur coal from India. Sulfur is largely present as organic sulfur and therefore cannot be removed by the usual coal-cleaning methods. Greater desulfurization at 800° C. was obtained with three American coals of lower sulfur content. The desulfurizing effect was increased further by addition of aluminum oxide to the coal before carbonizing in the presence of ammonia. Alumina promotes decomposition of the ammonia and a stable aluminum sulfide is not formed in the coke. Sulfur compounds contained in the gaseous, liquid, and solid products of the carbonization were determined.

Products: Properties, Utilization and Analysis

4.7 Billion Pounds of Chemicals From Four Olefins. Robert S. Aries and William Copulsky. *Chem. Eng.*, **57** (1950), pp. 116-7.

Tremendous growth has taken place in the use of olefins for chemical production since 1940. The most important of these olefins are ethylene, butylene, propylene, and isobutylene, all of which are derived from petroleum. Total production of these four olefins from 1940 to 1950 is estimated at 20 billion pounds. Production increased from 606 million pounds in 1940 to 3,343,000,000 pounds in 1950. Today olefins as raw materials account for 10 percent of the total production and value of synthetic organic materials. Products made from them include ethyl alcohol, Ethyl Fluid, antifreeze materials, vinyl and styrene plastics, synthetic rubber, isopropyl and butyl alcohol, and many others. A statistical table shows the quantities of the various olefins in the years between 1940 and 1950 and the utilization of these olefins for making various compounds.

High-Efficiency Laboratory Fractionization. IV. A Metal Laboratory-Still. O. G. Dixon. *Jour. Soc. Chem. Ind.*, **69** (1950), pp. 191-2.

Many efficient glass laboratory stills have been described in the literature but experience with such stills shows that the chief disadvantage lies in the ease with which the column and flask suffer damage during operation or when being cleaned. The author describes a laboratory still constructed entirely of stainless steel, the column of which was packed with gauze rings for high efficiency. The equipment can be used for

HAVE YOU SEEN THIS NEW BOOKLET?

Condensed information on the function, applications and resultant economies obtainable through this modern development in Entrainment Separation.

The effectiveness of METEX MIST ELIMINATORS has been demonstrated by installations of several years' standing both in this country and abroad. Used in vacuum pipe stills, scrubbing towers, knock-out drums, evaporators and similar equipment and equally adaptable to new or existing installations, they have effected such marked economies as:

1. 95% or better entrainment removal
2. End-product quality secured even with lower-cost raw materials
3. Operation at full capacity without contamination
4. Practical elimination of re-runs

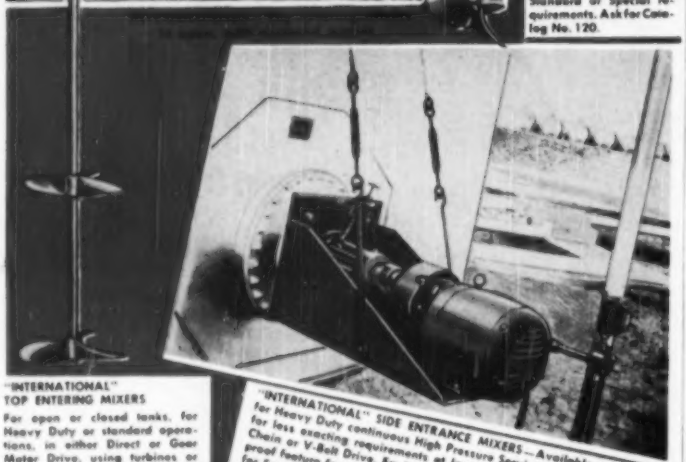
Write for your copy today. The coupon below is for your convenience. No obligation, of course.

METAL TEXTILE CORPORATION
633 EAST FIRST AVE., ROSELLE, N. J.

Metal Textile Corp.
633 East First Ave., Roselle, N. J.
I would like to have a copy of your new booklet, Metex Mist Eliminators
Name..... Title.....
Company.....
Address.....
City..... State.....

"International"
Refinery
Mixing Equipment

"INTERNATIONAL" PORTABLE MIXERS
Superior in Flexibility. Mechanically correct. Light and precision built for years of continuous, trouble-free service. Direct or Gear Motor Drive — Electric or Air Motor, in any size to meet Standard or Special requirements. Ask for Catalog No. 120.



"INTERNATIONAL" TOP ENTERING MIXERS
For open or closed tanks, for Heavy Duty or standard operations, in either Direct or Gear Motor Drive, using turbines or propellers. Units come completely assembled, ready for use, with standard or special Flange drilling. Catalog No. 120.

"INTERNATIONAL" SIDE ENTRANCE MIXERS — Available in Types for Heavy Duty continuous High Pressure Service, and also in types for less exacting requirements at lower cost, in Gear Motor, Silent Chain or V-Belt Drive. Equipped with ball thrust bearings, and leak proof feature for re-packing from outside of tank. ½ to 30 H.P. Ask for Special Catalog No. 72.

Call on INTERNATIONAL'S vast experience for assistance in solving your Mixing and Blending problems. Our Engineering staff is at your service — write for catalogs and complete information on Top Entering, Side Entrance and Portable Mixers, which are free for the asking, and no obligation, of course.

INTERNATIONAL ENGINEERING, Inc.
DAYTON, OHIO
NEW YORK — 12 PARK ROW
CHICAGO — 607 S. WABASH AV.
DISTRICT REPRESENTATIVES
IN PRINCIPAL CITIES

Science and Technology

fractionations above or below atmospheric temperature or pressure, and can handle material that is solid at normal temperatures. The method of construction of the still is given and is also illustrated.

Unsaturation in Petroleum as Indicated by Halogen Addition Methods. A. WINWARD and F. H. GARNER. *Jour. Soc. Chem. Ind.*, **69** (1950), pp. 147-53.

It is well known that straight-run gas oils have appreciable bromine and iodine values but it is also believed that no unsaturated hydrocarbons are present. When the Hanus reagent is used, namely iodine bromide, the reaction is largely one of substitution and is caused by certain aromatic hydrocarbons that distill in the gas oil boiling range. Twenty-three hydrocarbons were tested, including 17 aromatic hydrocarbons. The only hydrocarbons that gave appreciable iodine values were mesitylene and isodurene, both of which possess a 1:3:5-trialkyl substituted aromatic ring. It is thought possible, therefore, that this structure is responsible for the apparent unsaturation of the higher-boiling petroleum fractions.

Infrared-Mass Spectrometer Combination Method for Light Hydrocarbon Analysis. M. J. O'NEAL, JR. *Analytical Chem.*, **22** (1950), pp. 991-5.

The author describes a method for the complete analysis of C_1 to C_4 paraffin-mono-olefin hydrocarbon solutions that does not require the usual low temperature distillation or other separation methods. Cis- and trans-2-butene can be determined. The basis of the procedure is a simple total pressure computation that permits all components (including the total butenes) to be based upon mass spectrometer data. The butene split is made by means of data from the infrared spectrometer. This takes advantage of the superior accuracy of the infrared data for butenes but retains the accuracy and wide range of applicability of the mass spectrometer for the lighter hydrocarbons. The method can also be applied to higher hydrocarbons of the gasoline range where the mass spectra of any two or more components are similar, but where there are differences in the infrared absorption spectrum.

New Purdue Course Studies Oil Refining Practices

Purdue University Calumet Center, division of Technical Institutes, this fall is introducing a new field of study, petroleum refining practices. Emphasis will be on refinery practices and operation and product control and treatment, with accompanying courses in mathematics, physics, and chemistry.

Registration and counseling for the courses which are available under the G. I. Bill will be held at the local Purdue office, 5935 Hohman Avenue, Hammond, Ind. Purdue is located in Lafayette, Ind.

OU Graduate School Adds New Course and Fellowship

A graduate fellowship to begin September 1 in the school of chemical engineering at the University of Oklahoma has been established by The Ma-

WeldELLS®

Let's get down to fundamentals: — There is only one *permanent* way to join pipe — only one joint as strong as the pipe itself — the properly *welded* joint.

A properly welded joint involves just two basic factors — a good fitting and good welding. In the WeldELL line you have not only the fitting that expresses the highest development in engineered strength and closely controlled metallurgy . . . you also have the fitting with features that enables the welder to do his job better and faster.

The WeldELL line embraces the widest range of sizes, weights, types and materials. In many sizes and types there are no fittings BUT WeldELLS!

TAYLOR FORGE

TAYLOR SPIRAL PIPE is available in a broad range of sizes and thicknesses. Coupon brings Spiral Pipe Bulletin 493.

TF

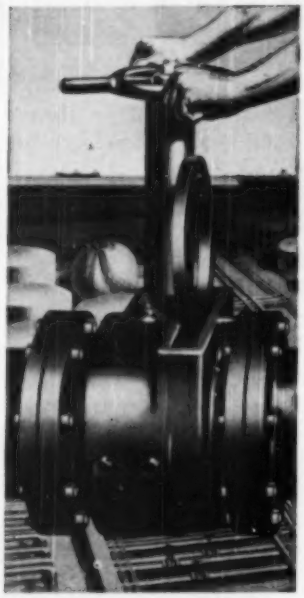
TAYLOR FORGE & PIPE WORKS
P. O. Box 485, Chicago 90, Illinois
Offices in all principal cities: *Eastern Plant:* Carnegie, Pa.
Western Plant: Fontana, Calif.

☐ Please send Catalog 484 covering welding fittings and forged steel flanges.
☐ Send Bulletin 493 covering Taylor Spiral Pipe and related fittings.

NAME_____
POSITION_____
COMPANY_____
STREET ADDRESS_____
CITY_____ ZONE____ STATE_____

Mail to Taylor Forge & Pipe Works, P. O. Box 485, Chicago 90, Ill.
507-1050

NOW BLIND RIGID LINES
in the COST-CUTTING
HAMER hand wheel operated way



When Hamer Line Blind Valves were introduced years ago, the old expensive and hazardous way of blinding pipe lines with a spectacle bolted between companion flanges became obsolete. The Hamer family of positive, one-man operated line blinding units has now grown until there is *a Hamer Line Blind Valve for every application*—EVEN FOR BLINDING RIGID LINES where no endwise movement is possible.

The new "RIGID" Line Blind Valve solves the problem of blinding inflexible lines in refineries, process plants, tankers and other ships ... wherever rigid piping installations must be opened and closed. *It's speedy and cost-cutting*—one man can reverse the plate in one minute. It's *safe*—enclosed plate slot prevents spilling line fluid. *It's positive*—there's nothing like a solid plate for a permanent, leak-proof shut-off.

Positive shut-off without pipe line movement!

Actuated by the hand wheel, a smooth-turning ball bearing mounted ring gear moves the sliding internal sleeve in a straight line to clamp and release the plate, eliminating the need for spreading the line. "RIGID" Line Blind Valves conform to A. S. A. Standards for face-to-face dimensions of steel wedge gate valves. In planning new layouts, or modernizing existing installations, use a gate valve for blocking but specify Hamer "RIGID" Line Blind Valves at every point where quick, one-man operated, POSITIVE SHUT-OFF will be required.

LEFT—"RIGID" LINE BLIND VALVE

RIGHT—SPOOL-TYPE LINE BLIND VALVE

SPEED, ECONOMY, SAFETY IN BLINDING FLEXIBLE LINES!

There are Hamer Line Blind Valves for every blinding application. All models feature cost-cutting "one-man, one-minute" operation, positive shut-off, and long service life. Write for full information.

Illustrated below are: 1—Spool-Type, side hand wheel. 2—Spool-Type, upright hand wheel. 3—"Tee" and "Ell" Type. 4—Economy 3-Bolt Type.

SEND FOR CATALOG

HAMER LINE BLIND VALVES • Non-Stick PLUG VALVES

OIL TOOL COMPANY

2919 GARDENIA AVENUE, LONG BEACH 6, CALIFORNIA

loney-Crawford Tank and Manufacturing Company of Tulsa. The fellowship is open to chemical engineering students who have already completed one year of graduate study.

A new course in petroleum refinery engineering will be added to the graduate program in September. It will deal with design of various pieces of refinery equipment, as well as the assembly of these elements into the complete design of a process.

LETTER

Suggests Further Empasis On Bubble Caps Article

To The Editor:

I was rereading Mr. Zenz's most interesting article on Skirted Bubble Caps (June, 1950, Petroleum Refiner) when it occurred to me that perhaps the most significant discovery of this study was not given its deserved emphasis. This is understandable because the phase that is about to be discussed is generally under the control of the mechanical staff rather than process men.

Perhaps the most time and money-consuming operation in the building of a pressure vessel is that of installing trays that are perpendicular to the axis of the vessel and are of satisfactory flatness. A review of usual building specification tolerances will show that permissible deviation in cap height of from .15" to .25". Minor degrees of tray tilting may increase this variation as well as lack of exact plumbness of the vessel when it is erected in the field. In other words, a combination of circumstances, all within accepted trade tolerances can produce a change in "H" (Figure 3) among the various caps of as much as .25" to .50" even without considering the change in liquid level due to hydraulic gradient. You will note that the author expresses concern over waves of ½" (pages 104, 105) which would cause momentary flow unbalance while it has been shown that accepted tolerances among the fabricating trade produce "permanent waves" of this magnitude.

What then is the answer? I believe that Mr. Zenz has shown the way. The idealized cap should have practically a constant pressure drop over a wide range of vapor flow and this drop should be high enough to insure equal vapor distribution to all caps. This condition is obtained in the conventional cup at high vapor rates for the drop is high enough to make the difference in drop among the various caps become significant in the normal design. Mr. Zenz's caps show a trend toward a stabilized drop at all flows. Perhaps with the above thoughts in mind, further experiments could improve these characteristics.

The achievement of the above described "ideal" cap is indeed a prize for the degree of manufacturing precision now required costs a needless several thousands of dollars per vessel and to require closer tolerance would be prohibitive.

It is hoped that Mr. Zenz is able to continue his most worth while research and that he will give us the benefit of his findings.

(signed) Paul Hall

4403 Jonathan
Bellaire, Texas

These Tubes—

go in to stay—because the ZINC is in to stay!

CHASE ANTIMONIAL ADMIRALTY

(a patented alloy)

Antimony is an exceptionally efficient dezincification inhibitor *—when used in the right proportions.*

Admiralty with an antimonial content of less than .007% (the minimum set forth in Chase Patent No. 2,061,921) cannot be depended on to guard against dezincification under all conditions. For lasting service over a wide range of applications, .015% is the rock-bottom figure. Chase makes *doubly* sure you get this minimum percentage despite normal commercial variations—by using a nominal antimonial content of .035%.

Only Chase can make the *patented* Antimonial Admiralty offering this extra protection. Get the facts today.

Special stocks of ANTIMONIAL ADMIRALTY Condenser Tubes in Chase Warehouses: NEW YORK, BALTIMORE, NEW ORLEANS, LOS ANGELES, SAN FRANCISCO

also carried by—
Vinson Supply Co., Tulsa
Standard Brass & Mfg. Co., Houston

Chase

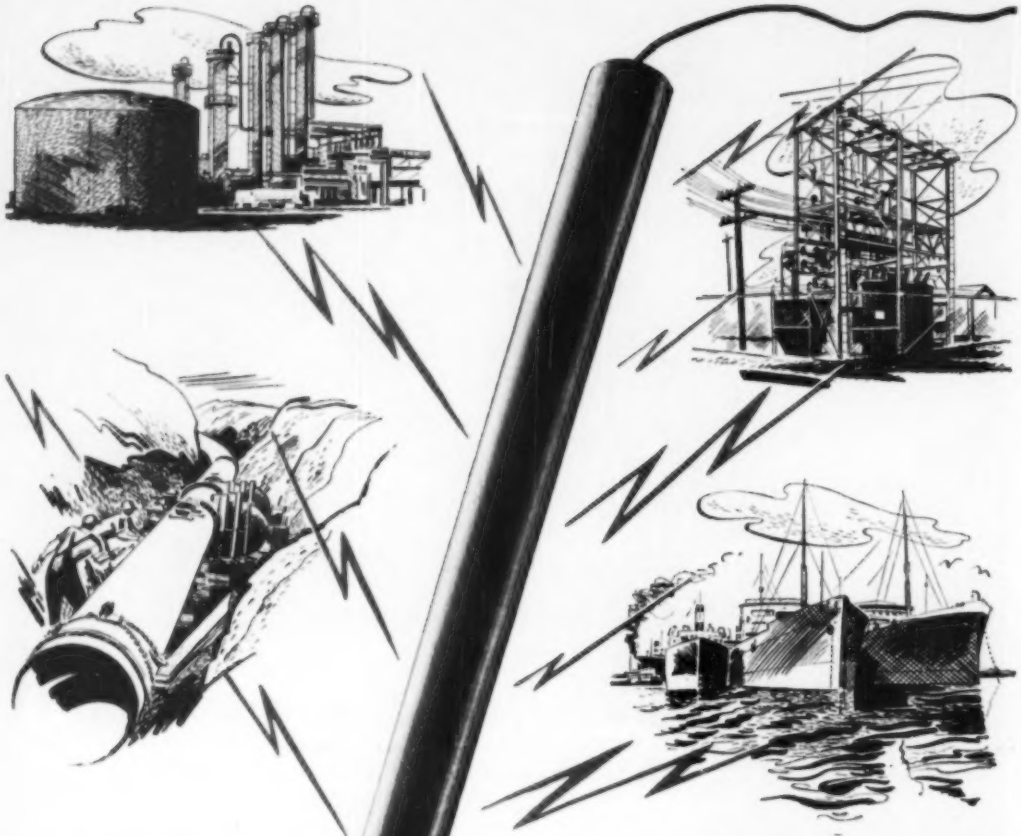
WATERBURY 20 CONNECTICUT

the Nation's Headquarters for
BRASS & COPPER

SUBSIDIARY OF KENNECOTT COPPER CORPORATION

THIS IS THE CHASE NETWORK . . . *handiest way to buy brass*

ALBANY ATLANTA BALTIMORE BOSTON CHICAGO CINCINNATI CLEVELAND DALLAS DENVER DETROIT HOUSTON INDIANAPOLIS KANSAS CITY, MO. LOS ANGELES MILWAUKEE MINNEAPOLIS NEWARK NEW ORLEANS NEW YORK PHILADELPHIA PITTSBURGH PROVIDENCE ROCHESTER ST. LOUIS SAN FRANCISCO SEATTLE WATERBURY



PROTECT METAL STRUCTURES POSITIVELY UNDER ALL CONDITIONS!

"NATIONAL" GROUND ANODES

● Regardless of what the job is . . . how corrosive the environment – whether wet or dry, hot or cold – you can depend upon "National" ground anodes to provide efficient, positive protection against underground and underwater corrosion.

"National" ground anodes have proved themselves in 20 years of successful operation in many different parts of the country. They outlast other materials by a wide margin. They do not have to be dug up and replaced every couple of years. Because they use a controllable current source, it is simple and economical to adjust their protective output to match exactly the requirements of any installation.

For complete details on "National" ground anodes, write to National Carbon Division, Union Carbide and Carbon Corporation, Dept PR.

MORE THAN DOUBLE THE USABLE LIGHT!

The biggest news since the invention of flashlights — the brand new leakproof "Eveready" battery — gives more than double the usable brilliant white light for critical uses than any other flashlight battery we ever made.

NO METAL CAN TO LEAK OR CORRODE

The terms "National" and "Eveready" are registered trade-marks of

NATIONAL CARBON DIVISION
UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street, New York 17, N. Y.

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
Foreign Department: U. S. A.

Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by HEINZ HEINEMANN

(From the Official Gazette, July 18, 25 and August 1 and 8, 1950)

REFINING

U.S.P. 2,515,197. Extensively Treating Petroleum Distillates. C. A. Cohen to Standard Oil Development Company.

Details are claimed for the preparation of a white oil from a distillate oil of the lubricating oil boiling range heavily treated with acid. The object of the process is the removal of suspended sludge particles and soluble petroleum sulfonates from the oil under treatment.

U.S.P. 2,515,217. Solvent Extraction Process. K. H. Hachmuth to Phillips Petroleum Company.

Details are claimed of a process for separating a mixture of liquefied butanes, butenes and butadiene according to their degree of unsaturation. The process makes possible the liquid-liquid extraction of these close boiling compounds under atmospheric temperature conditions.

U.S.P. 2,516,507. Absorption Separation Process for Hydrocarbons. P. H. Deming to Shell Development Company.

Details are claimed of a process for separating a gaseous or vaporizable mixture of three different hydrocarbons, such as a gaseous mixture of C_1, C_2 and C_3 hydrocarbons, which decrease in their tendency to be absorbed by a common liquid hydrocarbon absorption oil. The mixture of gaseous or vaporizable hydrocarbons is repeatedly countercurrently contacted with the liquid selective absorbent.

U.S.P. 2,516,614. Alicyclic Monocarboxylates in Hydrocarbon Extraction. M. Buis to Shell Development Company.

The liquid-liquid extraction of a hydrocarbon mixture with a selective solvent is carried out in the presence of less than 1 percent by weight of a salt of a polyvalent metal with an alicyclic monocarboxylic acid. Polyvalent salts of naphthenic acid are excluded. Zinc rosinate is an example of the additive used. Enhanced separation of the raffinate and extract phases is obtained by the additive.

U.S.P. 2,517,839. Recovery of Pure Cyclo-Olefins. P. H. Carnell to Phillips Petroleum Company.

The separation of cyclopentene or cyclohexene from their mixture with open chain mono-olefins of about the same b.p. is effected by contact with an aqueous solution of HF. Cycloalkyl fluoride in organic solution is formed, separated by fractional distillation and dissociated by heating.

U.S.P. 2,518,353. Purification of Oils. A. C. McKinnis to Union Oil Company of California.

The continuous separation of nitrogen bases from hydrocarbon oil, e.g. from crude petroleum, shale oil, coal tar fractions, or the like, is effected by means of an extracting solvent formed from ammonia or mono-di-, or trimethyl amines and a strong non-volatile polybasic inorganic acid in the presence of water.

U.S.P. 2,518,365. Wax Separation by Filtration. I. E. Pattillo to Socony-Vacuum Oil Company, Inc.

In the separation of paraffin wax from wax-bearing petroleum fractions, a wax cake of reduced oil content is obtained by first filter-pressing the paraffin distillate charge at a low temperature and then pressing a slack wax charge at a higher temperature through the same filter press containing the initially formed wax cake.

POLYMERIZATION AND CONVERSION

U.S.P. 2,515,369. Process for Catalytically Converting Hydrocarbon Oils. W. J. Degnen to The M. W. Kellogg Company.

Hydrocarbon oils are continuously converted (preferably cracked) to form high knock rating motor fuels by contacting a vapor stream of the oil superheated to a temperature not higher than 925° F. at high velocity with finely divided dispersed solid catalyst in an enlarged reaction zone into which the dispersed catalyst is continuously introduced and where it is maintained in motion. Deactivated catalyst is regenerated at a temperature higher than that of the superheated vapors and is then recycled without cooling.

U.S.P. 2,515,371. Method for Recovery of Powdered Catalyst in Conversion Operations on Gases or Vapors. J. W. Jewell to The M. W. Kellogg Company.

In the catalytic conversion of gases or vapors passing upwardly through a dense turbulent suspended catalyst phase, the residual catalyst material remaining in the reaction effluent after settling of the bulk of catalyst is removed by cyclone separators. The thus separated catalyst is discharged into an external collection hopper and is impelled into the catalyst settling zone.

U.S.P. 2,515,373. Catalytic Conversion of Hydrocarbons. P. C. Keith and J. W. Jewell to The M. W. Kellogg Company.

The method according to this patent is closely related to that of U.S.P. 2,515,371.

U.S.P. 2,515,646. Polymerization by Stannic Chloride. D. F. Gould to Allied Chemical & Dye Corporation.

A non-polymerizable hydrocarbon oil containing at least one of the polymerizable materials indene, coumarone, styrene or their homologs is subjected to the polymerizing action of $SnCl_4$ in the presence of not more than 50 percent by weight of the $SnCl_4$ of acetic or formic acid. Solid resinous products are obtained.

U.S.P. 2,516,097. Catalyst Sampler. R. E. Woodham and E. E. Volpi to Socony-Vacuum Oil Company, Inc.

In a continuous system for the conversion of hydrocarbons in the presence of comminuted catalyst particles, an apparatus claimed in detail is arranged for removing samples of the catalyst and fluids from the reaction vessel.

U.S.P. 2,516,683. Low Temperature Polymerization Catalyst and Process of Using Same. R. W. Dornte and J. F. McKay, Jr., to Standard Oil Development Company.

In the polymerization of isobutylene, $AlCl_3$ is dissolved in an alkyl chloride of 1-2 C atoms in a concentration of 0.1-0.01 percent. The solution is cooled to a temperature below —50° C. For each mol of dissolved catalyst 0.5-60 mols of a diolefin with 4-6 C atoms are added. This stable, non-polymerizing solution is added to an isobutylene feed cooled to —40° to —164° C. The isobutylene can be mixed with diolefin of 4-6 C atoms. Rapid copolymerization is effected.

U.S.P. 2,516,943. Apparatus for Catalytic Treatment of Hydrocarbons. E. M. Barber to The Texas Company.

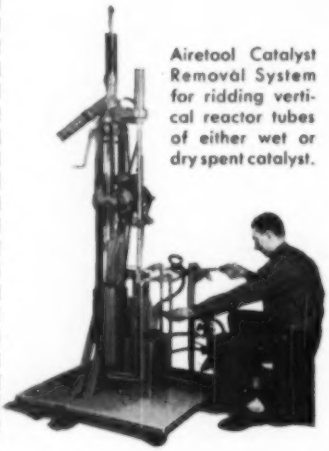
An apparatus is claimed for catalytic treatment of hydrocarbons, such as

These Tools lick your production and maintenance problems

Airetool double expansion tube cleaner with offset cone cutter for refinery tubes.

Airetool midget cleaner for removing lime, coke or scale deposits from small tubes.

Airetool ball bearing type expander for precision rolling of small tubes.



Airetool Catalyst Removal System for ridding vertical reactor tubes of either wet or dry spent catalyst.

Airetool Tube Rolling Control for fast, uniform expansion of tubes. Automatically controlled.

Full full details about how AIRETOOL cleaners, expanders and refinery accessory tools can help you lick your tube maintenance problems and raise production, write or wire The AIRETOOL Manufacturing Company, 316 S. Center Street, Springfield, Ohio.

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

There's an AIRETOOL Tube Cleaner and Tube Expander for Every Type of Tubular Construction.

BRANCH OFFICES: New York, Philadelphia, Chicago, Houston, Tulsa, Baton Rouge

Patents

cracking, re-forming, dehydrogenation and desulfurization. Segregated increments of the catalyst are moved through an elongated reactor while the hydrocarbons to be treated are passed transversely through the catalyst increments.

U.S.P. 2,517,042. Method for Transferring Fluidized Solid Particles. J. F. Skelly to The M. W. Kellogg Company.

Details are claimed for transferring fluidized solid contact material between separate contact zones, e.g. from a zone of low pressure to a zone of high pressure.

U.S.P. 2,517,066. Manufacture of Polymer Gasoline. C. W. Watson to The Texas Company.

Details are claimed of a process for the catalytic polymerization of gaseous olefins derived from catalytic cracking of oil and containing a small amount of molecular oxygen. The feed is passed in contact with an oxidation catalyst at elevated temperature and pressure to convert the oxygen present to oxygenated hydrocarbon compounds before polymerizing the hydrocarbons.

U.S.P. 2,517,139-41. Pyrolytic Conversion of Hydrocarbons. R. B. Smith to Sinclair Refining Company.

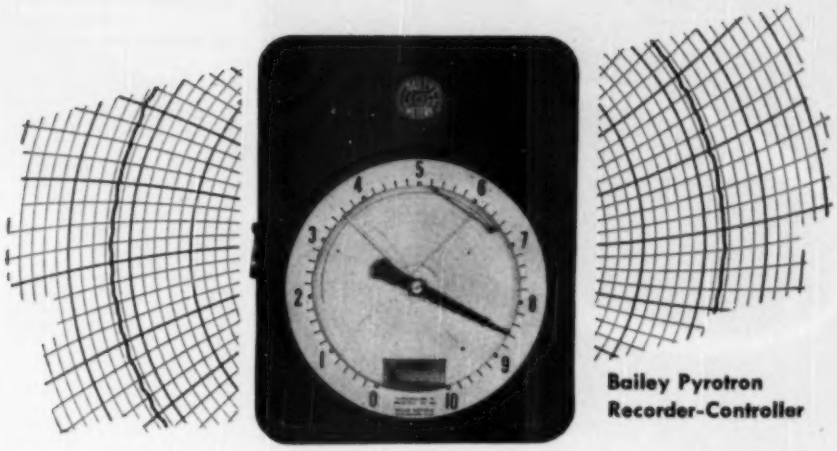
In the fluid catalytic conversion of hydrocarbons, catalyst fines carried off in suspension in the regeneration combustion gases are recovered by subjecting the suspension to ultra-sonic vibrations of the order of ½ megacycle per second. The agglomerates of catalyst fines thus formed are separated from the gases and returned to the conversion zone. According to U.S.P. 2,517,140 the catalyst fines contained in suspension in a non-residual liquid fraction obtained from the converted hydrocarbon vapors are coagulated by the same means. According to U.S.P. 2,517,141 residual catalyst fines are recovered by the same means from their suspension in the converted hydrocarbon vapors prior to the fractionation of these vapors.

U.S.P. 2,517,525. Catalytic Reaction Apparatus. L. W. T. Cummings to Sun Oil Company.

A catalytic reaction apparatus is claimed for conducting alternate endothermic and exothermic reactions, e.g. for catalytic cracking or otherwise converting hydrocarbons and regenerating spent catalyst in cyclic operation. The apparatus is especially adapted for storage within the contact mass of a large proportion of the exothermic heat evolved during the regeneration period for use during the subsequent on-stream period. A plurality of perforated annular trays is positioned concentrically and spaced apart from one another in a cylindrical shell. Each of the trays retains a bed of granular contact material. The top and bottom walls bridging the spaces between each two of the trays are imperforate.

U.S.P. 2,517,720. Method of Producing Propylene Polymers and Surface Active Agents Derived from said Polymers. R. E. Schaad to Universal Oil Products Company.

A propylene tetramer is produced by reacting a mixture of propylene and a



Bailey Pyrotron
Recorder-Controller

Looking for Better Temperature Instruments?

...Then check these features of Pyrotron Electronic Resistance Thermometers...

FUNDAMENTAL ACCURACY

Bailey Pyrotron Resistance Elements are made of highest purity platinum—the material used by the National Bureau of Standards in establishing basic standards for temperatures from −190°C to +660°C.

THREE TYPES OF CONTROL

Pyrotron Controllers may operate: on-off electrical systems by either electronic relays or electric contacts, modulated electronic systems, or air-operated systems. Two temperatures may be recorded on the same chart and controlled by a single instrument.

FACTS PUT INTO USABLE FORM

Bailey Pyrotrons may be arranged to put temperature facts into convenient usable forms. If two or more temperatures are related, they may be recorded as continuous records on the same chart for easy comparison. The average of several temperatures or the difference between two temperatures may be recorded as a single continuous record which may be retransmitted to a distant point or used to actuate a control system.

EASY INSTALLATION

Bailey Pyrotrons do not require careful leveling or protection against vibration. Three ordinary copper wires are all that is needed to connect each temperature sensitive element with the recorder. Power may be taken from any 115 volt 60 cycle circuit.

MINIMUM MAINTENANCE

The absence of galvanometers, batteries and standardizing equipment, together with the use of interchangeable unit assemblies, reduces Pyrotron maintenance to the vanishing point.

ABUNDANT POWER

A separate motor drive for each temperature furnishes abundant power to operate a recording pen, a controller and an alarm switch.

For the full story on this unusual electronic resistance thermometer which is suitable for ranges between −300°F and 1200°F, ask for Bulletin No. 230-C. P-21

BAILEY METER COMPANY

1043 IVANHOE ROAD • • • CLEVELAND 10, OHIO

Controls for Processing

TEMPERATURE
PRESSURE
% OXYGEN
% COMBUSTION
FLOW
LEVEL
DENSITY
RATIO

Okadee Valves have the perfect seal for butane, propane, and other hard-to-hold light fluids and gases. Their precision lapped seats and discs assure complete and positive shut-off. One-quarter turn fully opens or closes the valve. Being non-lubricated, they require no maintenance or service.

Where fast, full opening and closing is essential . . . where leak-proof shut-off is paramount, such as on this butane - propane loading rack in a Gulf Coast refinery, Okadee Valves are the perfect installation.

Ask your WECO Representative or write for catalog for complete details of OKADEE VALVES.

EASY OPERATING • POSITIVE SEAL • NON-LUBRICATED • LONG LIFE

CHIKSAN JOINTS WECO UNIONS WECO COMPOUNDS

WELL EQUIPMENT MFG. CORP.

Subsidiary of Chiksan Company
HOUSTON 1, TEXAS
Exclusive Sales Representative Outside Mid-Continent Area
CHIKSAN COMPANY
Brea, Calif. Chicago 3, Ill. Newark 2, N. J.
Export Sales: CHIKSAN EXPORT COMPANY, Brea, Calif. Newark 2, N. J.

WECO

Manufacturers and Distributors of Oilfield, Refining, Marine and Industrial Equipment

Patents

propylene polymer fraction with less than 12 C atoms or a recycle fraction of the process with a solid P-containing polymerization catalyst.

U.S.P. 2,517,900. Method and Apparatus for Liquid Phase Hydrocarbon Conversion. J. W. Loy to Phillips Petroleum Company.

Details are claimed of a method and an apparatus for high pressure, liquid phase hydrocarbon conversion with the use of a moving particulate catalyst which during the conversion adsorbs a substantial quantity of liquid hydrocarbon which is stripped from the catalyst during its regeneration by means of hydrocarbon gases and vapors.

U.S.P. 2,518,270. Reactor. F. T. Barr to Standard Oil Development Company.

An apparatus is claimed which allows to control the temperature of endothermic or exothermic reactions in the presence of a powdered fluidized catalyst by means of a heating or cooling fluid in heat exchange with the fluidized mixture of catalyst and reactants. The heat exchange elements of the apparatus give relatively even distribution of the surface and are easily accessible and replaceable.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,515,279. Process of Heat Control in Catalytic Hydrogenation Reactions. B. J. C. Van der Hoeven to Koppers Company, Inc.

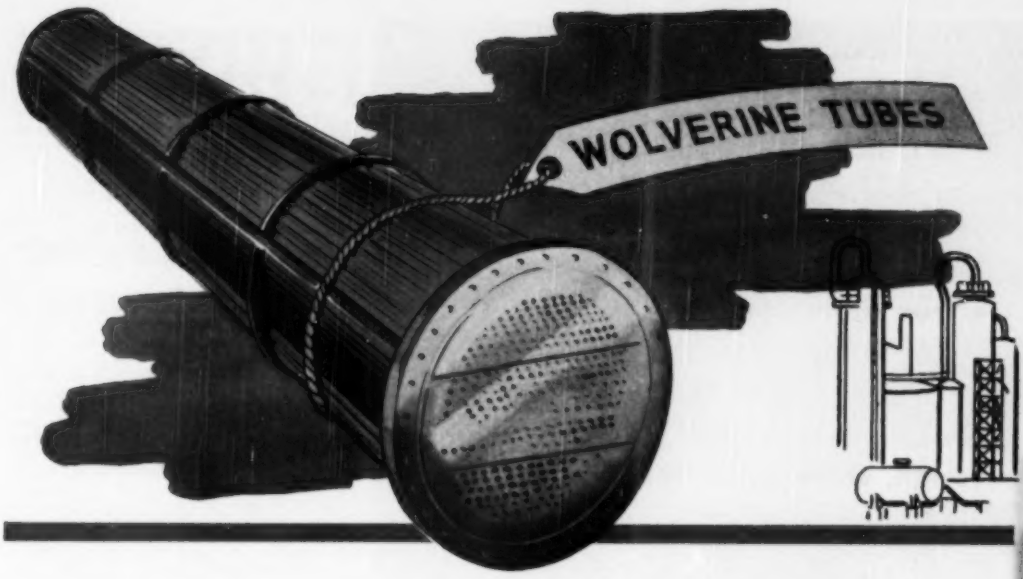
Details are claimed for vapor phase hydrogenation catalysis in a single stage heat exchange converter of the jacketed type. A heat transfer fluid is circulated through the jacket in contact with the walls of the catalyst-containing units. Effective temperature control is obtained to dissipate the heat of reaction. Cyclohexane can be produced by means of this process from benzene.

U.S.P. 2,516,126-7. Separation of Organic Compounds. G. G. Lauer, H. J. Passino, and J. R. Segesser to The M. W. Kellogg Company.

In the catalytic hydrogenation of an oxide of carbon, a hydrocarbon-rich phase is obtained which contains also organic acids and non-acidic oxygenated organic compounds, all with at least 4 C atoms in the molecule. The organic acids in this mixture are separated as their Ca, Ba or Mg salts by a process claimed in detail.

U.S.P. 2,516,699. Processing of Hydrocarbon Synthesis Products. C. E. Hemminger to Standard Oil Development Company.

In the treatment of the crude reaction products formed in a Fischer-Tropsch synthesis in the presence of a fluidized iron catalyst, a low boiling gasoline fraction containing olefins, an intermediate gasoline fraction boiling in the C_4 hydrocarbon range to about 350° F., and a heavy naphtha-gas oil fraction containing oxygenated hydrocarbons are separated from one another. The olefins of the first named fraction are poly-



WHEN YOU RETUBE . . .

● When you require new tubing — either for a complete retubing job or for a single tube replacement—consider the advantages offered by Wolverine tube.

Among the most important factors to consider when selecting tube for your condensers is, obviously, the anticipated life of the tube you contemplate using. How long will it perform before it gives up? That, as you know, depends upon how well the tube was made — how carefully and how often it was inspected as it progressed through the various stages of production.

Another vital consideration is to make sure that the tubes used are of the proper alloys to withstand the corrosion conditions to which the tubes are subjected.

For these reasons—and many more—we ask you to consider the use of Wolverine seamless, non-ferrous condenser tubes—the tubes that are quality-controlled every step of their manufacture—to give you long, dependable service. And by virtue of that long, continuous performance that they promise, you gain a most valuable consideration in keeping your maintenance cost down to a minimum.

Let Wolverine trained technicians help you determine the proper alloys for the tubes you should use under your particular operating conditions.

If you haven't a copy of our brochure, Condenser Tubes, we'll be glad to send one upon request.

WOLVERINE TUBE DIVISION
Calumet & Hecla Consolidated Copper Company
INCORPORATED
MANUFACTURERS OF SEAMLESS, NON-FERROUS TUBING
1431 CENTRAL AVE. • DETROIT 9, MICHIGAN

PLANTS IN DETROIT AND DECATUR, ALA.
Sales Offices in Principal Cities

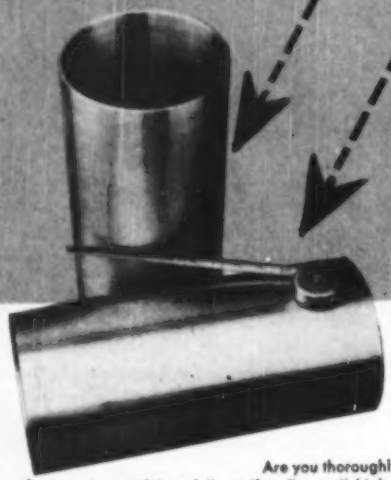
DURASPUN

18-8 Cylinder Liners

• True diameters

• True wall thicknesses

• Tough, close-grain metal



Are you thoroughly familiar with the superior qualities of "centrifugally cast" high alloys . . . such as these cylinder liners, for example?

Centrifugally cast metal is exceptionally uniform, close-grained and strong. It is free of pits and pockets. It is capable of passing very rigid tests. And the practical advantage is that as long as there is a central circular hole, almost any outside shape can be cast. Some of our customers want their castings centrifugal even though considerable boring and other machining is necessary to finish the piece.

We recommend our centrifugal casting service if your requirements call for the characteristics outlined above. Our high alloy foundry is modern in every respect and staffed by metallurgists and foundrymen of many years' experience with both centrifugal and static castings.

THE DURALOY COMPANY

Office and Plant: Scottdale, Pa. • Eastern Office: 12 East 41st Street, New York 17, N. Y.

F. B. CORNELL & ASSOCIATES

Patents

merized by corresponding treatment of this fraction, the intermediate fraction is subjected to a treatment in the presence of bauxite and added steam at a temperature of 850-950° F. to improve its octane number, and the third fraction is separately contacted with bauxite at temperatures of 800-900° F. and thereafter subjected to hydrogenation under specified conditions.

U.S.P. 2,516,940. Method for Treating the Products of Synthesis Gas Conversion. G. B. Arnold, H. V. Hess, and M. M. Stewart to The Texas Company.

The conversion products of a CO/H_2 mixture obtained under synthesis conditions are separated into an aqueous phase, a liquid hydrocarbon phase, and a gas phase at a temperature of 175-300° F. and a pressure sufficient to maintain normally liquid products in the liquid phase. The aqueous phase is extracted with a hydrocarbon solvent under special conditions to form a hydrocarbon-rich extract containing non-acidic oxygen-containing organic compounds, and a water-rich phase containing organic acids. The extract phase combined with the liquid hydrocarbon phase is subjected to catalytic hydrogenation with a portion of the gas phase so as to convert aldehydes and ketones contained therein to alcohols which are separated.

U.S.P. 2,517,035. Catalyst for Hydrocarbon Synthesis. E. E. Sensel and R. A. Beck to The Texas Company.

In the synthesis of liquid hydrocarbons and organic oxygen compounds from CO and H_2 or olefins in the presence of a cobalt catalyst, this catalyst is promoted by 0.5-10 percent by weight of La_2O_3. The catalyst shall contain about 3 percent of magnesia.

U.S.P. 2,517,036. Supported Catalysts for the Conversion of Carbon-Monoxide-Containing Reactants. E. E. Sensel and M. M. Stewart to The Texas Company.

In the CO/H_2-synthesis of organic compounds at a temperature of 375-396° F. the catalyst employed comprises cobalt and a composite supporting material consisting of about equal proportions of uncalcined diatomaceous earth and alumina containing less than 0.8 percent of alkali metal compounds, stabilized with about 5 percent silica.

U.S.P. 2,518,315. Synthesis of Hydrocarbons. C. E. Hemminger to Standard Oil Development Company.

Details are claimed of a Fischer-Tropsch synthesis process by contacting a synthesis gas containing H_2 and CO in the approximate ratio of 1.3 at a temperature of about 705° F. with a dense, turbulent, fluidized mass of a finely divided iron catalyst promoted with about 1.1 percent of potassium at a pressure of about 386 psi. A hydrocarbon fraction of motor fuel boiling range is obtained which is rich in branched chain paraffins and olefins, aromatics and naphthenes and has an octane number of about 84.

U.S.P. 2,518,337. Slurry Handling. R. W. Krebs to Standard Oil Development Company.

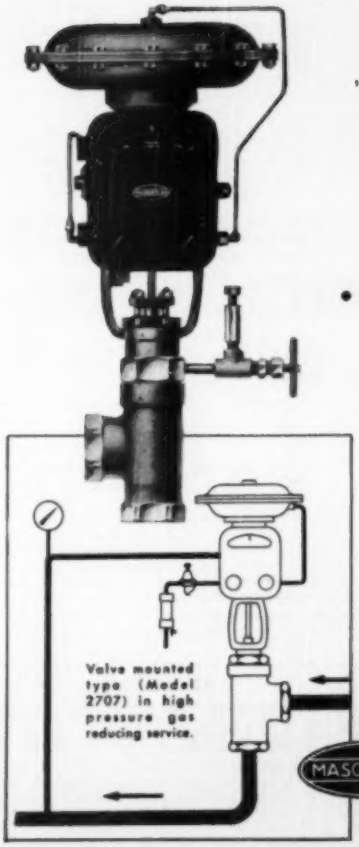
In the dewaxing of a hydrocarbon syn-

MASONEILAN MODEL 2700 PRESSURE CONTROLLER

Offers Accurate Proportional Control...

Precise Response...

Ease of Adjustment



Valve mounted type (Model 2707) in high pressure gas reducing service.

...yet is Moderately Priced

Masoneilan No. 2700 Pressure Controllers are especially designed for applications requiring accurate control when expensive instruments are not warranted. The pneumatic feedback, usually found only in more elaborate proportional controllers, assures precise response. The Control point setting mechanism provides accuracy of adjustment and easily read expanded index scale. Control action is reversible with either bourdon or bellows. The controllers are furnished in two case styles: a universal case for panel mounting; and a specially designed case for valve or wall surface mounting.

Applications include — pump governors, steam pressure reducing stations, gas well pressure reduction, and many others requiring small to intermediate proportional band.

MASONEILAN

MASON-NEILAN REGULATOR COMPANY

1182 ADAMS STREET, BOSTON 24, MASSACHUSETTS, U. S. A.

Sales Offices or Distributors in the Following Cities: New York • Syracuse • Chicago St. Louis • Philadelphia • Houston • Denver • Pittsburgh • Cleveland • Cincinnati • Tulsa Atlanta • Los Angeles • San Francisco • Salt Lake City • El Paso • Boise • Albuquerque Detroit • Charlotte, N. C. • Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

YOU can STOP RUST . . . PREVENT RUST . . . on *all* your rustable metal surfaces with RUST-OLEUM. Every day, rust eats away on your metal tanks, pipelines, drilling and pumping machinery, metal buildings, roofs and fences. Yet, rust *can* be stopped and protection given economically with RUST-OLEUM.

For more than a quarter of a century RUST-OLEUM has been *proved* under severe conditions of weather, fumes, salt air, salt spray, and other rust producing conditions. Railroads, shipyards, builders, refiners . . . nationally known users* in almost every field of industry . . . have found RUST-OLEUM the economical way to stop rust and prevent further rust. Architects, builders, engineers, maintenance men now specify RUST-OLEUM for primer, "shop coat", and finish coats.

RUST-OLEUM adds extra life to metal buildings, equipment and other metal surfaces and can be applied over already rusted surfaces without extensive surface preparation. Yet, RUST-OLEUM costs no more than most quality materials.

RUST-OLEUM not only protects—it beautifies as well! RUST-OLEUM is available in a large selection of colors including aluminum and white. It spreads evenly . . . and dries free of brush-marks in 4 to 12 hours, depending on conditions, to a tough, pliable film that protects against rust.

Be sure you get *only* genuine RUST-OLEUM for positive protection against rust! Specify *RUST-OLEUM* to your contractor or architect on any new construction, remodeling or maintenance work.

RUST-OLEUM is stocked and sold by leading industrial distributors in all principal cities of the United States and Canada. See Sweets for complete catalog and nearest source of supply, or write us direct for complete information.

**Names on request*

RUST-OLEUM CORPORATION

2554 Oakton Street • Evanston, Illinois

Patents

thesis catalyst containing formed wax which is removed by treatment with a solvent, sufficient solvent is removed from the catalyst to form a non-pumpable slurry. This slurry is converted to a foam (e.g. by treatment with a gas), and the foam is returned to the synthesis reaction zone.

U.S.P. 2,518,354. Method of Maintaining Catalyst Activity in a Dehydrogenation Process. R. N. Meinert and H. G. Vesterdal to Standard Oil Development Company.

Butenes and alkylated aromatics are dehydrogenated in the presence of steam over an iron oxide catalyst on a MgO base promoted by K_2O. The steam and hydrocarbon feed streams are heated to a temperature of 1000-1400° F. A K_2O forming compound is injected into the heated feed stream. The resulting mixture is passed at 1000-1400° F. into contact with the catalyst. The activity of the catalyst is maintained by supplying enough of the K_2O forming compound to replace K_2O lost in the withdrawal of dehydrogenated hydrocarbons.

CRACKING AND RE-FORMING

U.S.P. 2,515,374. Catalytic Conversion of Hydrocarbons. P. C. Keith and J. W. Jewell to The M. W. Kellogg Company.

Details are claimed of a continuous process for the catalytic cracking of high boiling hydrocarbons. The catalyst is introduced into the cracking and regeneration zones in finely divided condition and a suitable concentration of the catalyst is maintained in these zones.

U.S.P. 2,516,134. Method for Making Feed Stock for a Furnace Black Process. L. G. Moligue to Phillips Petroleum Company.

Details are claimed of a process for cracking a virgin gas oil. While a portion of the oil is thermally cracked, another portion is catalytically cracked under specific conditions. Certain gas oil fractions from both these operations are combined and again thermally cracked. At least a portion of the gas oil thus obtained is used as feed stock to a carbon black process.

U.S.P. 2,516,848. Method of Producing Butadiene from Petroleum and Petroleum Fractions. A. Brasch to Electronized Chemicals Corporation.

Petroleum or petroleum fractions are cracked by repeated treatment with high speed electrons, each of the consecutive treating periods being very short. A catalytic material, such as an oxide of the II, III, or IV periodic group, may be present. Butadiene is formed.

ALKYLATION

U.S.P. 2,515,237. Production of Beta-Ethyl-Naphthalene. W. M. Kutz to Koppers Company, Inc.

A mixture of liquid naphthalene and ethylene is heated in contact with a silica-alumina catalyst at a temperature above 275° C. until an alkylate is obtained which contains at least 3 parts of

STAINLESS STEEL MECHANICAL AND PRESSURE TUBING

These are common sizes. Intermediate sizes, larger or smaller diameters, heavier or lighter walls, or geometric shapes other than round also are available.

OUTSIDE DIAMETER	GAUGE RANGE	OUTSIDE DIAMETER	GAUGE RANGE
3/8"	16-25	1-11/16"	10-20
7/16"	16-25	1-3/4"	10-20
1/2"	14-25	1-7/8"	10-20
9/16"	14-25	2"	9-20
5/8"	14-24	2-1/8"	9-20
11/16"	14-24	2-1/4"	9-20
3/4"	13-24	2-3/8"	8-20
13/16"	13-24	2-1/2"	8-20
7/8"	12-23	2-5/8"	8-20
15/16"	12-23	2-3/4"	8-20
1"	11-23	2-7/8"	8-20
1-1/16"	11-22	3"	8-20
1-1/8"	11-22	3-1/4"	8-16
1-3/16"	11-22	3-1/2"	8-16
1-1/4"	11-22	3-3/4"	8-16
1-5/16"	11-20	4"	8-16
1-3/8"	11-20	4-1/4"	8-16
1-7/16"	11-20	4-1/2"	8-16
1-1/2"	10-20	4-3/4"	8-16
1-9/16"	10-20	5"	8-16
1-5/8"	10-20		

The above sizes are available in types 304, 309S, 310, 316, 317, 321, 347 and 430. Type 302 is available in a limited range of sizes for ornamental use.

STAINLESS STEEL PIPE

NOMINAL PIPE SIZE	OUTSIDE DIAMETER	SCHEDULE 40S STANDARD PIPE WALL THICKNESS	SCHEDULE 10S LIGHT WALL PIPE WALL THICKNESS
1/8"	.405	.068	.049
1/4"	.540	.088	.065
3/8"	.675	.091	.065
1/2"	.840	.109	.083
3/4"	1.050	.113	.083
1"	1.315	.133	.109
1-1/4"	1.660	.140	.109
1-1/2"	1.900	.145	.109
2"	2.375	.154	.109
2-1/2"	2.875	—	.120
3"	3.500	—	.120
3-1/2"	4.000	—	.120
4"	4.500	—	.120

The above Pipe Sizes are available in the Chrome-Nickel analyses of Republic ENDURO Stainless Steel.

ELECTRUNITE

Stainless Steel Tubing and Pipe

● NOW . . . up to and including 5" O.D. . . . ELECTRUNITE Tubing made of time-tested Republic ENDURO® Stainless Steel.

In 1947, the ELECTRUNITE Size Range was expanded to include the pipe sizes listed at the left. Today, Steel and Tubes keeps pace with your expanded requirements by offering a complete range of stainless steel tubing sizes produced by the continuous welding method.

Republic—world's largest producer of stainless and alloy steels—offers you prompt metallurgical assistance with any problem involving the use of stainless steel tubing or pipe. Write, wire or phone *today* for further information.

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Dept.: Chrysler Bldg., New York 17, N. Y.

REPUBLIC STEEL

Republic ELECTRUNITE

STAINLESS STEEL TUBING AND PIPE

Coordinated Service

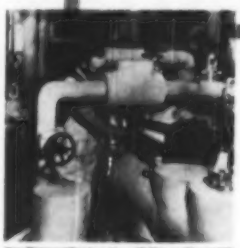
FOR THE ENTIRE NATION

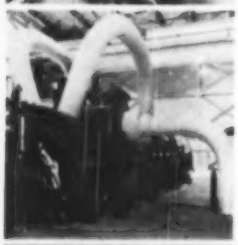
PABCO

"PRECISION MOLDED"

85% MAGNESIA and "PRASCO"

HIGH TEMPERATURE INSULATIONS





* Only PABCO approved Engineering Service Units are privileged to display the above emblem.
* Strategically located throughout the United States to best serve industry.
* Each unit offers its own extensive localized stocks of material.
* Competent insulation engineers, skilled mechanics—plus the advantages of factory co-ordinated experience.
* Reliable duplication of any job in any locality—including materials, workmanship, application methods.

MAY WE REFER YOU TO THE PABCO ENGINEERING SERVICE UNIT NEAREST TO YOUR JOB

THE PARAFFINE COMPANIES, INC.

PABCO

475 Brannan Street, San Francisco 19 — 295 Fifth Avenue, New York 16

Manufacturers of Heat Insulation Since 1920

Patents

beta-ethylnaphthalene for each part of alpha-ethylnaphthalene.

U.S.P. 2,518,307. Automatic Control of Catalyst Promoter in a Hydrocarbon Conversion Process. J. L. Groebe to Phillips Petroleum Company.

In the alkylation of hydrocarbons with olefins in the presence of a catalyst promoted by a minor amount of a hydrogen halide in the reaction mixture, the extent of alkylation is continuously controlled by passing infrared light rays through the alkylation effluent under conditions such that an electric impulse is produced corresponding in magnitude to the concentration of unreacted olefin in the effluent. The amount of hydrogen halide present in the reaction mixture is automatically controlled in response to the magnitude of the electric impulse received.

DESULFURIZATION

U.S.P. 2,516,837. Process of Regenerating an Aqueous Alkali Solution. J. Happel and S. P. Cauley to Socony-Vacuum Oil Company, Inc.

Details are claimed for the regeneration of an aqueous alkali solution used in the removal of mercaptan from hydrocarbons and containing weakly acidic sulphur compounds and a small amount of an oxidation promoter.

U.S.P. 2,516,876. Desulfurization of Light Petroleum Hydrocarbons. W. A. Horne and J. F. Jungé to Gulf Research & Development Company.

Low boiling petroleum hydrocarbons are desulfurized by passing their vapors over initially unreduced nickel oxide supported on activated alumina at a temperature of 600-800° F. and a pressure of 100-500 psi. in the presence of hydrogen. The passage of the vapors is discontinued before 60 percent of the nickel has been converted to nickel sulfide, whereupon the contact material is regenerated.

U.S.P. 2,516,877. Desulfurization of Heavy Petroleum Hydrocarbons. W. A. Horne and J. F. Jungé to Gulf Research & Development Company.

The process of this patent for the desulfurization of high boiling petroleum oil or crude is closely related to the process of U.S.P. 2,516,877. A treating temperature of 750-950° F. and a pressure above 100 psi. (preferably 100-1000 psi.) are here employed.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,515,245. Process of Regenerating a Fluidized Fischer-Tropsch Catalyst. W. J. Mattox to Standard Oil Development Company.

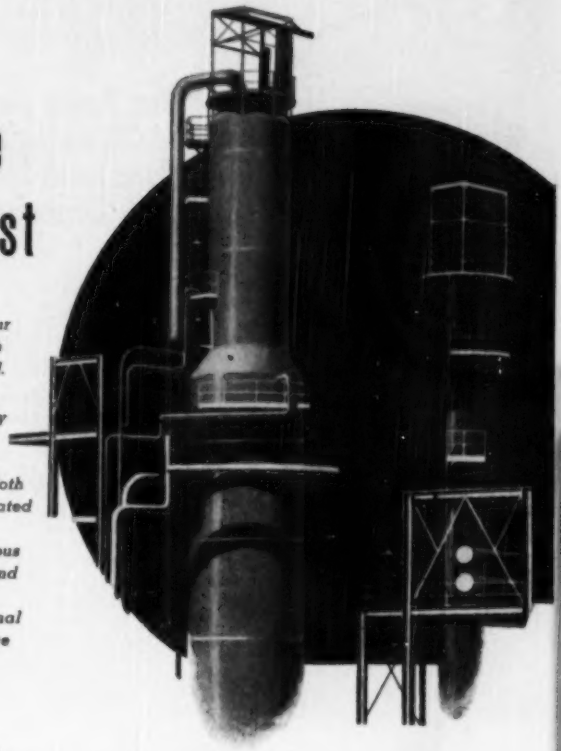
A carbonized Fischer-Tropsch synthesis iron type catalyst is contacted with steam or CO_2 at a temperature of 500-1100° F. The oxidizing atmosphere shall be such that oxidation of the iron catalyst is obtained in preference to a combustion of carbon. The thus oxidized

How to Cut Corrosive Crude Processing Cost

PROBLEM: *To minimize cost of distillation of sour crudes and production of lube fractions with minimum decomposition and maximum yield.*

DESIGN: *Combination vacuum unit providing very close processing controls, one of 5 similar units representing the latest improvements in bubble-type refinery equipment design. Both atmospheric tower and vacuum tower fabricated of stainless-clad steel to resist high-temperature corrosion, economically. Judicious spacing of equipment for minimum piping and use of heat exchangers to avoid excess processing heat loss, for maximum operational efficiency. Provision for maximum turbulence without entrainment at bubble-caps, for product quality.*

END RESULT: *Operating economies and high-quality product achieved by equipment with low first cost and long service life, while resisting corrosion from sulfides and organic chlorides in sour crudes.*



In foreground is shown atmospheric tower of distillation unit engineered for construction with Lukens Stainless-Clad Steel by Foster Wheeler Corporation and fabricated and erected in the plant of a prominent Eastern refiner by Wyatt Metal & Boiler Works.

The above case is not unusual. It is typical of the results achieved with newly developed, more efficient processing equipment. And wherever design, fabrication and materials selection must be critically coordinated, you will find the economical answer in applied *Lukenomics*. For Lukenomics combines the experience of designers, engineers and equipment builders with Lukens' knowledge of materials and their application, gained over 140 years as the world's leading producer of specialty steel plates, heads and steel plate shapes.

You'll find it pays to put Lukenomics to work on your equipment problems. There are progressive fabricators who can do this for you. Get in touch with them, or write our Manager of Marketing Service, stating your problem. Lukens Steel Company, 404 Lukens Building, Coatesville, Pa.

LUKENS

LUKENS STEEL COMPANY

BETTER PRODUCTS FOR BETTER EQUIPMENT

A User of Acid Sludge Pumps Reports:

"Our Pump rods lasted 22 times longer when hard-faced with Colmonoy"

His Problem: In handling highly abrasive material in acid sludge pumps, pump rods (1⅛" x 28" long) had to be repacked every eight hours, and completely replaced every twenty-four hours. Cost of replacement part alone: $45.00.

His Solution: He tried *Spraywelding** a few discarded rods with *Colmonoy No. 6*, an extremely wear and corrosion resistant hard-facing alloy. He then found that the packing lasted sixty hours, almost eight times as long as before (Colmonoy No. 6 has a very low coefficient of friction), and that the average Spraywelded rod didn't require replacement until working 573 hours, better than 22 times the life of a new rod.

Not only did the hard-faced pump rod outlast a new one many times over, but it cost less than half as much as a new rod to start with. Added to this were the impressive savings found in reduced maintenance labor, and in less lay-up time of the pump.

Colmonoy stands for a complete line of hard-facing alloys. Only a complete line can meet the various challenges of impact, abrasion, and corrosion, either singly or in combination. Colmonoy alloys come in forms to suit many applications: rod, paste, powder, wire, and castings.

Write for general literature or tell us of your particular problem for more detailed information.

The Spraywelder, shown spraying a pump rod used in handling caustic solutions.

*Spraywelding is a Colmonoy hard-facing process. It combines metallizing and welding. A powdered Colmonoy alloy is sprayed on the worn part, using a powder metallizing gun called the Spraywelder. The overlay is then fused, or welded to the part with a standard acetylene torch.

Spraywelding has these advantages:

Less material is used because the thickness of the overlay is easily controlled to within .010"

Less time is required to spray than to handweld, and because of the accuracy of spraying, less time is required to finish the part.

A Spraywelded surface is free of pinholes; no patching or discards. Part distortion is held to a minimum.

Write us for the name of the nearest Spraywelding shop or for information about equipping your plant for Sprayweld work.

ORDER FROM YOUR LOCAL JOBBER

WALL COLMONOY CORPORATION

HARD FACING ALLOYS

19345 JOHN R STREET · DETROIT 3, MICHIGAN

Patents

catalyst is contacted with a free-oxygen containing gas at temperatures of 700-1400° F. to oxidize the carbon in preference to further oxidation of the catalyst. The regeneration can be carried out while the catalyst is in a fluidized state.

U.S.P. 2,516,967. Process of Forming Hydrogel Beads. M. P. Elam to International Minerals and Chemical Corporation.

Details are claimed of a process of forming hydrogel pellets useful for catalytic purposes, e.g. from a siliceous hydrosol.

U.S.P. 2,517,223. Preparation of Internally Oxidized Catalysts. R. M. Mantell to Allied Chemical & Dye Corporation.

A porous catalyst for dehydrogenation and other processes is obtained by mixing a finely divided metal useful in the preparation of active catalysts, e.g. Cu or Fe, with a solid substance which will decompose with evolution of a gaseous oxidizing medium while heating, e.g. a nitrate, compressing the mixture and heating the body of predetermined form thus obtained to a temperature of 300-675° C. to effect decomposition of the solid substance and oxidation of the metal.

U.S.P. 2,517,692. Regeneration of Aluminum Halide Sludges. J. M. Mavity to Universal Oil Products Company.

Deactivated aluminum halide-hydrocarbon sludge from a hydrocarbon conversion is regenerated by reacting it with a normally gaseous olefin and metallic Al. A liquid fraction separated from the reaction products is contacted with anhydrous hydrogen halide.

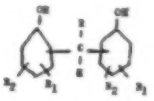
HEAVY OILS AND WAXES

U.S.P. 2,515,520. Rust-Inhibiting Lubricating Oil. W. M. Leath to Tide Water Associated Oil Company.

A mineral lubricating oil contains not less than .01 percent by weight of alkyl acid phosphate with 8-16 C atoms in the alkyl group and anisidine or phenetidine. This alkoxy aniline shall be present in an amount of not less than 3 times that theoretically required to react with said phosphate. The additive has a rust-inhibiting effect. The lubricant is especially adapted for the lubrication of steam turbines for marine use.

U.S.P. 2,515,908. Antioxidants for Oils and Oil Compositions Containing the Same. D. R. Stevens and A. C. Dubbs to Gulf Research & Development Company.

A mineral oil normally tending to undergo deterioration, e.g. a gasoline motor fuel oil or a lubricant, contains a small amount of a compound of the formula:



wherein R is furyl or alkyl substituted

GARLOCK PACKINGS and GASKETS

made of *Teflon*

Extremely Inert to Chemicals; Heat Resistant; Tough; Durable

GARLOCK packings and gaskets made of *Teflon* solve the problem of sealing against acids and chemicals of all kinds.

These *Teflon* products, fabricated in the GARLOCK factories, are unaffected by any acid and are highly resistant to all organic solvents and alkalies. They operate at temperatures from below −90° F. up to +500° F. and have high mechanical strength and a low coefficient of friction within that temperature range.

For use on valves, pump rods or shafts and any other equipment in the chemical industry, GARLOCK produces several types of braided and molded *Teflon* packings. For gasketing flanged joints of all kinds, including glass and porcelain flanges, *Teflon* envelope gaskets or solid *Teflon* gaskets are available in required sizes and shapes.

To avoid frequent shut-downs and reduce your packing costs, use GARLOCK packings and gaskets made of *Teflon* on all your equipment handling acids or chemicals. *Write for pamphlet.*

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK

Tulsa, Okla. Houston, Texas Los Angeles, Calif.

GARLOCK

ELLIOTT YR

.. the turbine that will fit in anywhere!

- True centerline supports
- Readily removable packing cases
- Sealed bearings
- Sealed governor
- Balanced double-seated valves
- Economical liner type bearings

Tailored to suit the actual requirements of your application because of the wide range of permissible modifications available to the basic design. These include speed governors, pressure governors, location of exhaust, auxiliary controls, etc.—all combined with spark-proof and totally enclosed construction. Write for fully descriptive bulletin.

H-725

ELLIOTT COMPANY

STEAM TURBINE DEPT., JEANNETTE, PA.

PLANTS AT

JEANNETTE, PA • RIDGWAY, PA. • AMPERE, N. J. • SPRINGFIELD, O. • NEWARK, N. J.

DISTRICT OFFICES IN PRINCIPAL CITIES

furyl, R_1 is a tert. alkyl radical with at least 4 C atoms, and R_2 is hydrogen or an alkyl radical with not more than 8 C atoms.

U.S.P. 2,516,136. Lubricating Grease Compositions. A. J. Morway and D. W. Young to Standard Oil Development Company.

Lubricating oil is thickened to a grease with 1-3 mol proportions of a metal soap of higher fatty acids and 1-2 mol proportions of a metal salt of a heterocyclic carboxylic acid of low mol wt. This acid has a 5-member heterocyclic ring with O or S as the hetero atom.

U.S.P. 2,516,137. High Temperature Lubricating Greases. A. J. Morway and J. J. Kolgenbach to Standard Oil Development Company.

A mineral lubricating oil is thickened to a grease with 5-50 percent by weight of a combination of 1-4 mol proportions of a metal soap of fatty acids with 1-4 mol properties of the salt contained in the Cannizzaro reaction products of a cyclic aldehyde of mol wt. below that of C_{11} aliphatic carboxylic acid and a strong base.

U.S.P. 2,516,138. Use of Furfural in Grease Manufacture. A. J. Morway to Standard Oil Development Company.

Mineral lubricating oil is combined in grease forming proportions with a saturated saponifiable fatty material and furfural. The furfural present is the liquid effluent from a furfural solvent refining process. An alkaline saponifying agent is added wherein the furfural is salvaged from said process and converted directly to a furoate and furfuryl alcohol.

U.S.P. 2,516,616. Lubricating Oil Detergent. J. O. Clay and D. H. Etzler to California Research Corporation.

Hydrocarbon oil contains a small amount of a polyvalent metal salt of a seleninic acid, e.g. one which has a direct C to Se linkage and contains at least 10 C atoms. Deterioration of the oil when exposed to oxygen is inhibited by the additive and the detergency is improved.

U.S.P. 2,516,654. Antioxidants for Mineral Oil Lubricants and Compositions Containing the Same. H. G. Smith, T. L. Cantrell, and J. G. Peters to Gulf Oil Company.

Mineral lubricating oil contains a minor amount of a non-resinous condensation product of 1 mol phenyl morpholine with 2-6 mols of N-dimethylaniline and 2-6 mols of formaldehyde. Oxidative deterioration of the oil is inhibited by the additive.

U.S.P. 2,516,838. Soluble Oil Base. K. F. Schiermeier to Shell Development Company.

An oil base soluble or emulsifiable in an aqueous medium contains 70-90 percent of a mineral lubricating oil and certain small amounts of an oil-soluble alkali metal salt of petroleum sulfonic acid, a base, a water-soluble salt of a higher hydroxy fatty acid and a certain type of a stabilizing agent. The product is useful as a rust inhibitor and metal working lubricant.

U.S.P. 2,516,844. Lubricant Composition. J. D. Bartleson to The Standard Oil Company (Ohio).

A mineral lubricating oil contains a small amount of an oil dispersable reaction product of 1 mol of a hydrocarbon unsaturated non-tertiary amine having a straight chain hydrocarbon radical of at least 12 C atoms and at least one olefinic double bond, e.g. hydrocarbon octadecenyl non-tert. amine, with 0.5 mol of P_2S_5 reacted at 400-600° F. The additive improves the oxidation stability of the composition.

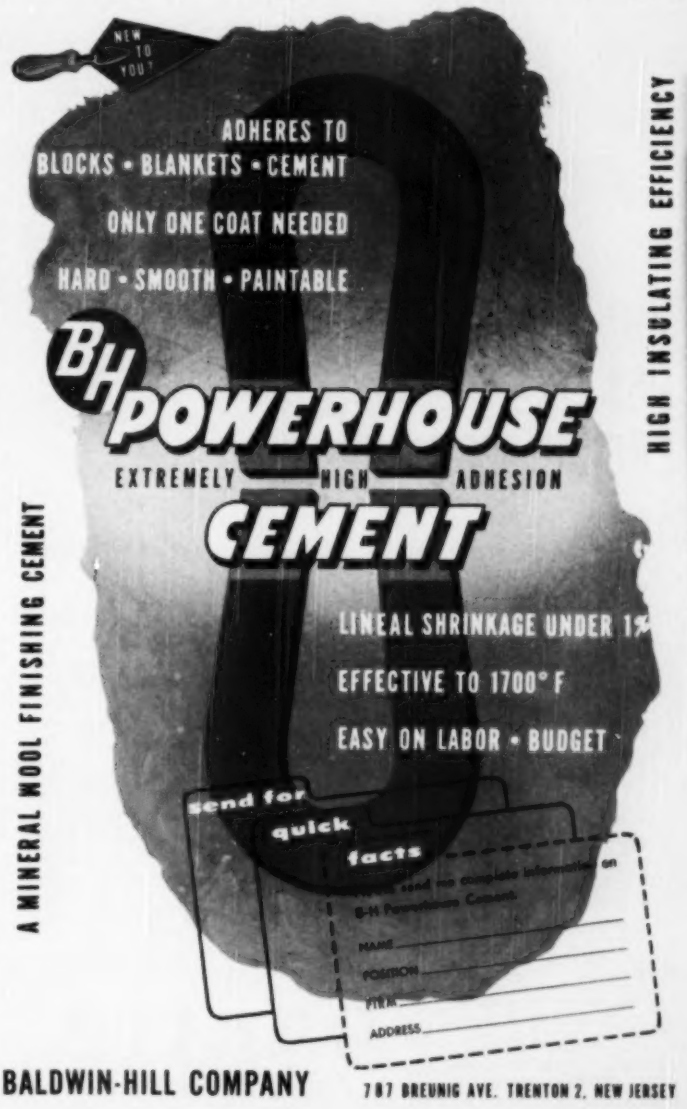
U.S.P. 2,518,372. Alkyl Substituted Thiophene Sulfonic Acid Salts as Detergents in Mineral Oil Compositions. O. M. Reiff and H. J. Andress, Jr. to Socony-Vacuum Oil Company, Inc.

A mineral lubricating oil contains a minor proportion of an alkyl substituted thiophene alkaline earth metal sulfonic acid salt. The alkyl substituent of this compound contains a chain of 10-30 C atoms in length. The additive improves the detergent properties of the oil.

Patents

U.S.P. 2,516,914. Emulsification-Inhibited Polyacrylate-Containing Oil Compositions. A. J. Revukas to Tide Water Associated Oil Company.

A mineral lubricating oil contains a dissolved small amount of a polymerized ester of the formula $CH_2=C(X)(CO_2R)$



Patents

wherein X is hydrogen or methyl and R is a saturated hydrocarbon group with 4-18 C atoms, and a small amount of a water-insoluble, oil-soluble salt formed by an alkyl acid ester of phosphoric acid with an alkylaminomethylaryol. While the first named additive improves the viscosity of the oil, the second additive inhibits the emulsification-enhacing tendency imparted to the oil by the first additive.

PETROCHEMICALS

U.S.P. 2,515,242. Method of Making Thiophenethiol. S. J. Lukasiewicz to Socony-Vacuum Oil Company, Inc.

Details are claimed of a method for making thiophenethiol by heating a mixture of separately preheated sulfur and n-butene, n-butenes, or butadienes.

U.S.P. 2,515,335. Method of Condensing 1,3-Dichlorobutene-2 with Aromatic Hydrocarbons. J. Cech and V. Albrecht to Bata, narodni podnik, Zlin.

Equimolecular proportions of aromatic hydrocarbons and 1,3-dichlorobutene-2 are condensed at temperatures up to 80° C. in the presence of a halide of Al, Fe, or Zn.

U.S.P. 2,515,928. Sulfur-Containing Liquids. S. J. Lukasiewicz and W. I. Denton to Socony-Vacuum Oil Co.

Valuable sulfur-containing derivatives are obtained by selective solvent extraction from the tar produced by separately preheating sulfur and an aliphatic hydrocarbon to a temperature such that on combining the preheated materials the mixture will have a temperature in excess of 850° F.

U.S.P. 2,516,477. Lecithin Stabilizer for DDT Petroleum Solutions. C. W. Moberly to Phillips Petroleum Company.

A supersaturated solution of DDT in a petroleum solvent contains 0.5-2.0 percent by weight of lecithin. This additive stabilizes the solution against precipitation of DDT at low temperatures.

U.S.P. 2,517,418. Production of Ethers of Phenyl Methyl Carbinol and Its Homologues. D. Faulkner and F. E. Salt to The Distillers Company, Ltd., Edinburgh.

A mixture of styrene and an aralkyl alcohol having a saturated hydrocarbon group attached to the hydroxyl group, e.g. benzyl alcohol, is heated with an acidic catalyst and phenylacetylene. Ethers of phenyl methyl carbinol are formed. Toluene sulphonic acid can be used as the catalyst.

U.S.P. 2,517,684. Ketones by Catalytic Reaction of Olefins with Aldehydes. E. C. Ladd to U. S. Rubber Company.

Propyl isobutyl ketone is produced by heating isobutylene and n-butyraldehyde in a proportion ratio of 1:6.5 at 70° C. for 45 hours in the presence of dibenzoyl peroxide.

U.S.P. 2,517,685. Preparation of Ketones by Catalytic Reaction of Diolefins with Aldehydes. E. C. Ladd to U. S. Rubber Company.

Isopentyl propyl ketone is produced by heating 1 part of isoprene with 1-20 parts of n-butyraldehyde in the presence of dibenzoyl peroxide to a temperature of 65-100° C.

U.S.P. 2,518,017. Chlorination of 1-Vinylcyclohexene-3. H. I. Johnson and A. P. Stuart to Sun Oil Company.

Monochlorovinylcyclohexene is prepared by introducing gaseous chlorine into a solution of 1-vinylcyclohexene-3 in an inert solvent at a temperature of 0-130° C.

U.S.P. 2,518,295. Production of Nitriles. W. I. Denton and C. J. Plank to Socony-Vacuum Oil Company, Inc.

For the production of nitriles with at least 2 C atoms, an aromatic hydrocarbon with 7-12 C atoms having at least one nuclear hydrogen replaced by a univalent, aliphatic, non-acetylenic hydrocarbon radical, or a non-acetylenic aliphatic hydrocarbon with 2-10 C atoms is contacted with gaseous ammonia at temperatures of 850-1250° F. in the presence of a molybdenum oxide catalyst containing an oxide of Cu, Ag, Au, Be, Mg, Zn, Cd, Th, Hg, Si, Ti, Ge, Zr, Zn, Hf, U, Pb, W, Mn, or Ce. Benzonitrile can, for example, be obtained from toluene.

U.S.P. 2,518,397. Process for the Production of Aliphatic Nitriles. W. A. Stover to Socony-Vacuum Oil Company, Inc.

A paraffinic hydrocarbon having at least one tert. C atom is contacted with an unsaturated aliphatic nitrile in the vapor phase at a temperature of 500-900° F. and under a pressure of at least 500 psi. Aliphatic nitriles of relatively high mol weight are obtained.

HEAT EXCHANGERS

cleaned chemically cuts out-of-service time

THE *quickest* and (in the long run) *cheapest* way to clean tubular heat exchangers is the *in-place* method of circulating hot solutions of chemical cleaning compounds. Much quicker, more thorough than lancing with air or steam. No danger of damage to metal surfaces as with rodding, drilling, or fish-sawing.

For the complete Oakite story on cleaning and descaling exchangers, other equipment, write nearest address below. Interesting literature—personal in-plant services freely available to you without obligation. Send today to Oakite Products, Inc., 44C Thames Street, New York 6, N. Y.

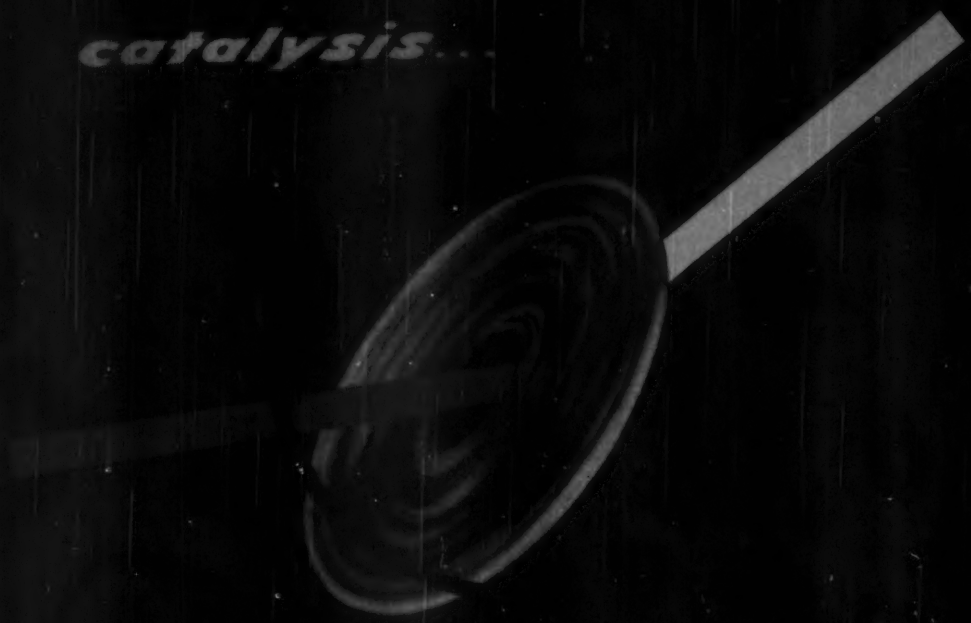
SEND for this FREE Booklet. It is full of useful information on general maintenance cleaning. Covers all divisions of the Petroleum Industry—production, processing, transportation, marketing.

Technical Service Representatives in Principal Cities of U. S. & Canada

OAKITE

PETROLEUM SERVICE DIVISION

catalysis...



and engineering "know how"

taking the catalysis out of the laboratory . . . out of the pilot unit into the refinery or chemical plant is a special function of the complete engineering and construction service—Foster Wheeler.

FOSTER WHEELER CORPORATION

165 BROADWAY, NEW YORK 6, NEW YORK

Designers and Constructors of all types of Catalytic Process Units

...with STEEL and STONE and "KNOW HOW"...

Foster Wheeler is building catalytic units in...

ENGLAND
3 big "Fluid" units and a large Poly plant are in various stages of construction.

IRAN
At Abadan, construction on another big "Fluid" unit nears completion.

BROOKLYN
Converting a Houdry into a modern TCC and building a new Poly unit.

Foster Wheeler construction crews are also at work building Catalytic process units in Spain, Canada, and the United States.

FOSTER WHEELER CORPORATION

165 BROADWAY, NEW YORK 6, NEW YORK

The Complete
Engineering and Construction Service
Anywhere in the World

process units
petroleum refineries chemical plants

NEW EQUIPMENT and Manufacturers' Literature

For copies of manufacturers' literature or more information about products described on these pages use the coupon below, circling the number shown for each item desired.

Pressure Blower

1 The new class 2000 pressure blower, manufactured by The Moore Company, is designed and constructed as a compact unit, including the special direct-drive motor mounted within the hub and housing. They are "tailor assembled for any one of an infinite number of performance requirements," feature a rotor to which the wheel is attached mounted on two heavy-duty, permanently greased and sealed bearings lubricated with silicone grease. The units, available in two size ranges, may be furnished in carbon steel, monel metal, stainless steel or any other workable metal available in sheet form. Belt drive units are available where direct drive units are not suitable.

Square Flush Case Gauge

2 A new gauge case for flush mounting gauges on panels has been announced by Helicoid Gage division, American Chain & Cable Company, Inc. This square case has the same bolt circle and the same round cut-out in the panel as standard round flush cases of the same dial size, yet the case takes up less room. The square front flange is less than the diameter of the conventional round front flange. The square case in dial sizes 4½, 6 and 8½ inches is particularly suitable for panel installation to match other square case instruments.

Oil Resistant Wire

3 A new gasoline and oil-resistant wire, called Geotrol, announced by General Electric's construction materials department, is "the first non-lead covered wire of its type to be listed by the Underwriters' Laboratories, Inc." It is designed for lighting circuits at refineries and similar places where oil and oil products are likely to cause deterioration of non-resistant wires. Conductors are insulated with vinyl compound and sheathed in a jacket that is highly resistant to petroleum products.

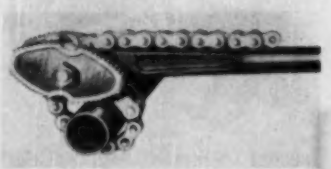
Large Volume Fan

4 A 22-foot fan developed by Hartzell Propeller Fan Company delivers 1,250,000 cubic feet of air per minute at 180 horsepower. Used in cooling towers in air conditioning and in the oil refining industry, where a vast amount of forced air is required, the fan as a single unit may be used in place of several smaller fans, cutting construction, maintenance and power costs in many cases. Plastic used in the fan absorbs vibration, has no fatigue limit and withstands the action of salt-water and mild acids and alkalies.

Fire Extinguishment

5 A booklet, "Fundamentals of Fire Extinguishment," has been published by Ansul Chemical Company. An illustrated discussion of what fire is, classes of fire and proper methods of extinguishment, it was originally introduced as an aid in training the company's salesmen.

Reversible Pipe Tongs



6 Without removing the tongs or loosening the chain, new "Vulcan" reversible tongs developed by J. H. Williams & Company will turn pipe in either direction. No time is lost in reversing the action. Outer jaws can be removed by taking out the single standard bolt and nut to make fittings tongs for narrow beads and flanges. These outer jaws have reversible ends. Four sizes for pipe and fittings from ¼ to 8 inches are available. Tongs are made from wrought steel, each chain is proof tested, and all parts are interchangeable.

Valve Diaphragm

7 A chemically inert valve diaphragm of Grinnell Company, Inc., can be used with Grinnell-Saunders dia-

FOR ADDITIONAL INFORMATION on products and literature mentioned in this section circle item numbers, cut out and mail this coupon. Prompt action is suggested so that data will be readily available.

PETROLEUM REFINER
BOX 2608, HOUSTON 1, TEXAS (R)

Please have manufacturers send me, without obligation, additional information about items from October, 1950, New Equipment Section whose numbers are circled below:

1	2	3	4	5	6	7	8	9	10	11
12	13	14	15	16	17	18	19	20	21	22
23	24	25	26	27	28	29	30	31	32	33
34	35	36	37	38	39	40	41	42	43	44
45	46	47	48	49	50	51				

Name _____ Title _____

Company _____

Street address _____

City and State _____

PLEASE PRINT OR TYPE YOUR COMPLETE MAILING ADDRESS

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 193.)

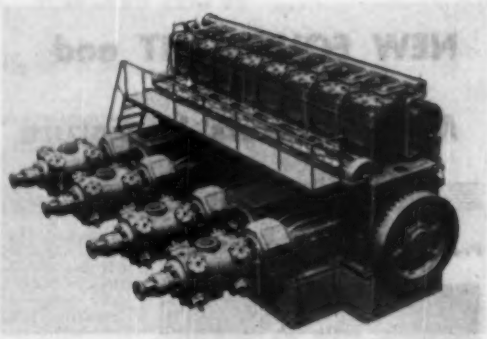
phragm valves which have been altered to permit the use of a backing sheet which cushions and protects the thermoplastic diaphragm. Valve bodies for use with the new thermo-plastic KEL-F diaphragms may be cast of corrosion resistant alloys or can be lined with glass, lead, rubber, or other impervious linings. Service conditions for the new diaphragms include pressures up to 100 psi. Service temperatures vary acording to the material and pressure in the pipe line with a tentative maximum temperature recommendation of 225° F. at the lower pressures. The diaphragms are not for use under continuous vacuum conditions.

Pilot-Operated Regulators

8 Information about pilot-operated pressure and temperature regulators is contained in a new 32-page booklet by Spence Engineering Company, Inc. Illustrated with photos, charts and tables, the new booklet discusses main valves, controls and strainers, and gives capacity and flow data as well as dimensions and weights. Detailed treatment is given such subjects as thermostats, desuperheaters, electrically-controlled regulators, strainers and flange standards.

Eight and 10-Cylinder Compressors

9 A new compressor, the Clark HLA, has been announced by Clark Bros. Company, Inc. Built in 2 sizes, an 8-cylinder model of 2000-bhp. and a 10-cylinder model of 2500-bhp., the new units operate at 330 rpm, have a bore of 17 inches and a stroke of 19 inches. A high compression unit, the HLA was developed to meet the need for larger compressors with flexibility of compressor cylinder arrangement. It will have application on gas transmission pipilens, natural gasoline plants, gas utilities, and chemical plants. The compressor has vertical power cylinders in line for maximum accessibility. Compressor and scavenging cylinders are in a horizontal position on one side of the crankcase. The 2000-bhp., HLA-8 has 4 compressor cylinders and the 2500-bhp., HLA-10 has 5 compressor cylinders. Power pistons incorporate oil cooled heads and oil cooled piston skirts. Thrust on the side of the cylinder is reduced by using long pistons and long connecting rods.



Flexible Metal Hose

10 Catalog 500 on flexible metal hose, issued by Atlantic Metal Hose Company, was compiled by the company's engineers to aid design and maintenance departments. Included with application and construction data are the U. S. Navy Department test table for bronze and steel hose, data on bending diameters, hydrostatic bursting pressures and the series of installation diagrams.

Shop-Assembled Boiler

11 A complete shop-assembled boiler, ready to place, hook up and operate has been developed by The Babcock & Wilcox Company. Larger plants with few skilled boiler operators may find it advantageous to use several of these smaller units rather than one or two of the larger "tailor-made" boilers which require field erection. Known as the B & W Integral-Furnace boiler, Type FM, the new unit is produced in standard sizes for loads ranging from 7000 to 25,000 pounds of steam per hour at pressures up to 25 psi. A water-tube boiler with a water-cooled furnace, it is compact and portable. Operated with push-button start and stop, the boiler has automatic control for handling variations in load. Controls are mounted on an enclosed cabinet.

Highest rates of heat transfer from the hot gases to the water in the boiler tubes are obtained through the use of 2-inch generating tubes. Firing may be by oil, gas or a combination of the two.

Suitable for outdoor service, the boiler is enclosed in a rigid steel casing, designed to permit expansion and contraction with temperature changes.

Alloy Castings

12 Michiana Products Corporation's new 2-color 16-page booklet describes the various heat-resistant, corrosion-resistant and abrasion-resistant alloy castings produced in its plant. Illustrations of many centrifugal and static castings are included with descriptions of properties of many of the alloys. Tables and charts show mechanical and physical characteristics.

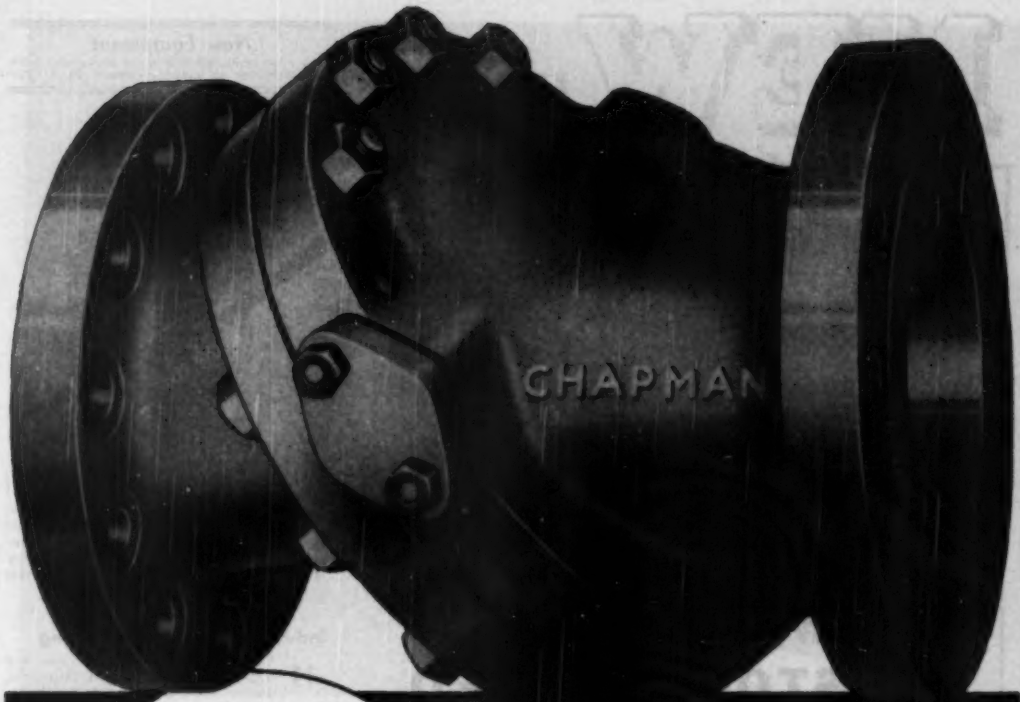
Air Well Bath

13 An apparatus used to test for elemental or corrosive sulfur compounds in petroleum products—their well bath—has been developed by Precision Scientific Company. Its design is said to meet the rigid specifications outlined in ASTM D-130 — 49T

Need More Data?

For additional information on New Equipment items or literature mentioned in this section, use the coupon on reverse side.

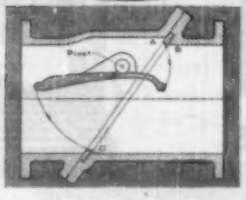
Prompt action is suggested so that data will be readily available.



STOP Destructive Pipe-Line Stresses

with CHAPMAN TILTING-DISC CHECK VALVES

IT'S THE VALVE WITH CUSHIONED CLOSING!



Cross-section of the Chapman Tilting Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

When you reduce slamming you reduce the hazard of rupturing pipe lines, opening up joints . . . . a host of maintenance problems.

That is why we suggest you investigate Chapman Tilting-Disc Check Valves. The balanced disc in this unusual valve lifts away easily in opening . . . rides smoothly on the flow . . . closes quickly but quietly. There's no slamming . . . minimum wear on valve parts and minimum stresses on pipe lines.

Special designs with dashpots are also available for use under unusual operating conditions, where no self-acting Check Valves can function satisfactorily.

Made in both iron and steel . . . pressures up to 3000 pounds.

You'll find it will pay you to write today for more information on this valve developed by Chapman. Request Bulletin #30.

The Chapman Valve Mfg. Co.

INDIAN ORCHARD, MASSACHUSETTS

NEW HEAT SAVING EFFICIENCY

...with MUNDET CUSTOM MOLDED 85% MAGNESIA

Now available in pipe covering and block insulation, Mundet 85% Magnesia permits new heat-saving efficiency. Precision manufacturing on the latest type of automatic equipment insures uniform standards. Extra durability is built into the insulation. It does not "powder", settle or disintegrate. It is unaffected by either steam or water leakage. It maintains an attractive, smooth finish. Precision pipe fit is assured, with no spaces left for the escape of heat. You benefit from the most modern manufacturing facilities for the production of heat insulation. Write for specification information and recommendations. Mundet Cork Corporation, Insulation Division, 7309 Tonnelle Avenue, North Bergen, N. J.

MUNDET

MUNDET

INSULATION FOR HIGH & LOW TEMPERATURE

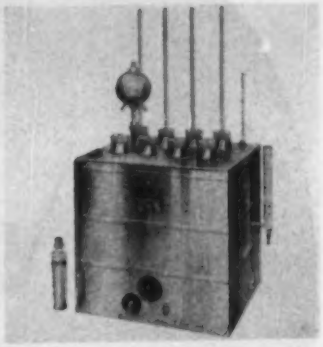
Mundet district offices are located in these cities:

ATLANTA 339-41 Elizabeth St., N.E.
BOSTON 57 Regent St., N. Cambridge 40
CHARLOTTE, N. C. 507 S. Cedar St.
CHICAGO 16 2601 College Grove Ave.
CINCINNATI 2 427 West 4th St.
DALLAS 1 601 Second Ave.
DETROIT 21 14401 Prairie St.
HOUSTON 1 Commerce and Palmer Sts.
INDIANAPOLIS 15 E. Washington St.
JACKSONVILLE 6, FLA. 800 E. Bay St.
KANSAS CITY 7, MO. 1420 St. Louis Ave.
LOS ANGELES (Haywood) 6116 Walker Ave.
NEW ORLEANS 16 315-25 N. Front St.
PHILADELPHIA 39 856 N. 48th St.
ST. LOUIS 9 3176 Brannon Ave.
SAN FRANCISCO 7 440 Brannon St.

In Canada: Mundet Cork & Insulation, Ltd. 35 Booth Ave., Toronto

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 193.)

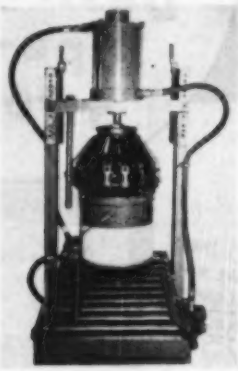


as well as Army-Navy ANF-48B and Army Air Corps, V.V. L-791, Method 530.5. The bath, completely insulated, is equipped with a sensitive hydraulic thermostat that gives automatic temperature control to within ½° C. Range from room to 100°C. The complete test can be run without adding water.

Industrial Water Conditioning

14 Control of scale, corrosion and algae is the subject of Aquatrol, Inc's. brochure, entitled "Water Patrol for Profit Control." Caricatures and colorful artwork describe a technical subject in an easy-to-understand manner. The reasons for the development of scale in water lines and boilers, the aggravation of corrosion and its attack on costly equipment, and the development of algae and bacteria to damage cooling towers and other water using equipment are shown.

Grease Pail Crimper



15 A machine for automatically crimping the lid on grease, paint and other viscous liquid containers is made by Barrett Manufacturing Company for use on all sizes of pails with removable tops. The crimper is designed to handle up to 720 pails per hour "with little or no manual labor, and when used in conjunction with an

extreme flexibility

Brown Fintube Sectional Heat Exchangers

are easily adaptable to changes in duty

● You'll get almost unlimited flexibility to meet changes in duties, plant re-arrangements, etc., with Brown Fintube Sectional Heat Exchangers. The banks can be changed over *easily* and *quickly*, to operate *efficiently* on almost any *new* and *different* duty. You simply add a few sections, remove a few sections, or change the series-parallel manifolding.

For the utmost in efficiency and economy use Brown's proven, welded fintube heat exchangers throughout your plant. Estimates and quotations furnished promptly. ***Write for Bulletin No. 481.***

BROWN FINTUBE'S 8 *advantages*

EXTREME FLEXIBILITY
Easily Adapted to Changes in Duty

NO OBSOLESCENCE
Avoiding Waste and Expense

FLANGED HEAD END ASSEMBLY
Eliminating Ground Joint Seals

EASY MAINTENANCE
Using Only Common Tools

CONTINUOUS OPERATION
No Shut-Downs For Cleaning

REDUCED STORES REQUIREMENT
Minimizing Investment and Handling

QUICK DELIVERY
Only a Few Hours in Emergency

INCREASED CORROSION ALLOWANCE
Longer Tube Life

THE BROWN FINTUBE CO.
ELYRIA, OHIO

SECTIONAL HAIRPIN HEAT EXCHANGERS

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 193.)

automatic filler takes over completely filling, crimping and batch stamping of entire output." Filling machine is designed to handle up to 900 pails per hour and ejects pails onto rollers leading to crimping machine.

Roller Tube Expander

16 A. L. Handerer's Sons have issued a bulletin describing their new roller tube expander, Type FC. This expander features an adjustable ball bearing thrust collar to reduce scoring and friction on the tube and produced by the thrust of the expander. It has been standardized for automatically controlled driving units, but the expander is a general purpose tool that can be driven by other means. Features are self feed, parallel rolling with tapered rolls, bullet-nose rolls to eliminate sharp ridges and properly selected tool steels.

Viscometer

17 A new brochure describing its Synchro-lectric viscometer has been published by Brookfield Engineering Laboratories, Inc. The viscometer, which reads directly in centipoises, may be used in the laboratory and at the point of process in a wide variety of industries to test, study, and control viscosity.

Close fractionation of hydrocarbons and high liquid output are operating features of TULSA TYPE Fractionating Columns.

TULSA TYPE is designed and fabricated to meet your specified operating conditions.

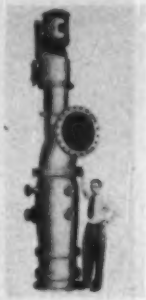
— Write for General Catalog —

FLINT STEEL CORPORATION

TULSA 1, OKLAHOMA

Mixing Unit

18 Developed by The American Well Works, the American Homomix, is a mix unit for uniformly blending a liquid and one or more chemicals or gases with water, sewage or industrial waste, without the use of a mixing tank. The Homomix which can be installed in a vertical, horizontal, or inclined position, is constructed of one or more mixing stages and forms part of the influent piping. Each stage consists of a diffusing impeller rotating in a blending chamber, driven by a continuous shaft direct-connected to the prime mover. A combination packing box and thrust bearing which are "built-in" features of the discharge head protect the prime mover against leakage and excessive thrust loads. Prime mover and rotating element may be removed without dismantling the unit. The mixing action is visible through a transparent observation port which may be opened for physical examination of the rotating elements. The Homomix is available in single or multiple units, in sizes from 6-inch to 24-inch inlet and outlet openings.



Corrosion Resistant Valves

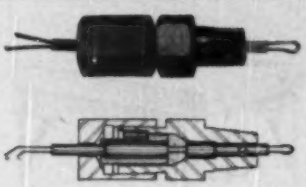
19 The addition of a new line of stainless steel valves to their regular line of cast steel valves has been announced by Pacific Valves, Inc. These valves are suited for refineries and chemical plants where handling corrosive fluids or atmospheric corrosion is a problem. They are available cast of Pacific's 316 Alloy (Type 316 Stainless Steel) or Pacific Alloy 20. The 150-pound, O. S. & Y., bolted bonnet gate valves, sizes ½ to 8 inches, is pictured. Others in the new line are: 150-pound, swing check valve with bolted bonnet, ½ to 6 inches; 150-pound, inside screw gate valve with screwed-in bonnet, ½ to 2 inches; 150-pound, O. S. & Y., Globe valve with bolted bonnet, ½ to 6 inches; 300-pound, O. S. & Y., Globe valve with bolted bonnet, ½ to 1½ inches; and 600-pound, O. S. & Y., Gate valve with bolted bonnet, ½ to 2 inches.

Thermocouple Gland

20 A new bare wire thermocouple gland, announced by Conax Sales Company, Inc., is designed to provide "the greater accuracy and quicker response of bare wire thermocouples without the leakage and expense usually associated with this method of temperature measurement and control of gases, vapors and liquids in a closed

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 193.)



vessel under positive or negative pressures."

Rapid interchangeability of all parts of this thermocouple gland permits the use of any thermocouple wire as required to meet various exacting individual requirements. This thermocouple gland may be used with temperatures from —100°F. to 1600°F. and will withstand pressures up to 4000 psi. They are available in models for standard 20 gage thermocouple wires, 14 gage thermocouple wires and for use with terminal block or conduit.

Insulating Materials

21 A method of flame spraying polyethylene coatings on steel tanks and processing equipment has been perfected by Houghton Laboratories. This process uses no solvents. After the tank has been sand blasted, polyethylene in powder form is blown through specially designed flame spray equipment. Deposited on the tank in melted form, the polyethylene sets up to "a tough, non-porous film which has unusual resistance to virtually all chemicals and corrosive materials."

Houghton has also announced a new material, produced in rod, tube or sheet form, for handling corrosive chemicals, etc. Odorless, tasteless, non-toxic, Hysol 6000 may be used at temperatures of 230° F. It is said to be impervious to concentrated hydrochloric acid and is not affected by dilute solutions of nitric and sulfuric acids. It is also impervious to water and other solutions which normally cause insulating materials to break down.

Chemical Feeders

22 Omega Machine Company has issued bulletin, No. 20-G14, on Omega Universal Feeders in three sizes, covering a chemical feeding range from 1 to 5000 pounds per hour. These feeders are designed to handle dry chemical or materials used in the treatment of water and in many process industries.

Accuracy, range and dust-proof operation are discussed. Diagrams show how automatic proportional control may be obtained. Included are photographs of the equipment, special application and data on computing dissolving chamber capacities for the feeders, etc.

Dri Coolers

23 Two small portable units and a medium size unit have been added to the line of dry cooling equipment manufacturing by The Marley Company, Inc. Models L and M, port-

KINNEY PUMPS
Always Dependable!

Kinney Heliquad Rotary Pumps are famous for performance. One of these HQA Pumps, in petroleum service since 1928, was inspected after 21 years on the job. It was found to be good as new, with no sign of wear at any point. Such a record is not surprising. A survey made on 1685 Kinney Pumps having an average age of 9.2 years, showed an average cost for repairs of only 1.65% of the original cost for each year's service! Materials pumped included all grades of petroleum products from crude oil to asphalt, coke oven by-products and tar. Kinney Heliquad Pumps are always dependable and cost less in the long run.

Write for Bulletin L48—the full story on Kinney Pumps

KINNEY MANUFACTURING COMPANY
3596 Washington St., Boston 30, Mass.
NEW YORK • CHICAGO • PHILADELPHIA
CLEVELAND • NEW ORLEANS • HOUSTON
LOS ANGELES • SAN FRANCISCO • SEATTLE

Pump delivers a continuous, non-pulsating flow. Handles fluids of all viscosities—from gasoline to molasses.
Heavy duty, anti-friction bearings maintain close tolerances for long lasting efficiency.
Steep helical rotors, driven by steel timing gears, pump fast — capacities up to 2100 U. S. G. P. M.

Anyway you figure it....

You get TWICE the VALUE with...

Clark DUO-STEP Leverage STEAM TRAPS

The amazing new Clark Duo-Step design actually *doubles* the drainage capacity of Clark Steam Traps. This means *double value* anyway you figure it. Now you can use smaller, less expensive traps for larger drainage jobs or get *twice* the drainage from traps you have been using.

Sound good? It is! Better look into Clark Duo-Step *today* and start saving real money on your steam trap requirements.

GET THE WHOLE AMAZING STORY...
SEND FOR THE DUO-STEP FOLDER TODAY!

THE CLARK MANUFACTURING COMPANY
1847 East 38th St., Cleveland 14, Ohio

Here's your Catalog for grating and stair treads

Full of applications, specifications and engineering data that will help solve your grating problems

Send for your copy Today

WHATEVER your grating problem . . . flooring, catwalks, stair treads, bridge surfacing, sidewalk doors, subway gratings, or any of the hundred and one uses for any industry . . . you'll want this big new Bulletin for complete information on construction details and *all* the advantages of Blaw-Knox Steel Gratings. Ask for Bulletin 2296.

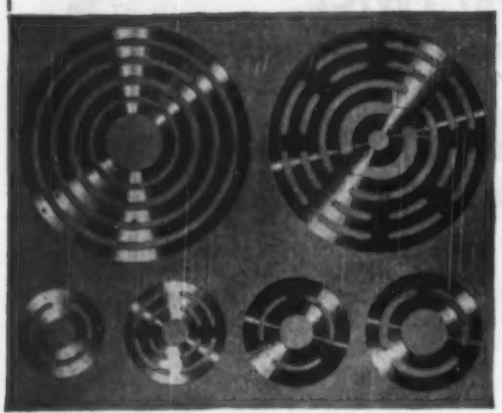
BLAW-KNOX DIVISION of Blaw-Knox Company
2005 Farmers Bank Bldg., Pittsburgh 22, Pa.

BLAW-KNOX ELECTROFORGED STEEL STAIR TREADS

Designed for tremendous strength against impact. Available with rolled diamond checker plate nosing (illustrated); twisted cross bar nosing; or abrasive nosing.

BLAW-KNOX ELECTROFORGED STEEL GRATING

Voss VALVE PLATES and DISCS FOR COMPRESSORS



ANY DESIGN • ANY SIZE • INDIVIDUALLY CUT AND GROUND

MACHINED—*not punched out*—which prevents cracks and strains thus eliminating breakage risk of fragments of broken plates getting in cylinders. Best obtainable alloy steels used to meet requirements. Oil hardened and tempered to correct hardness. Precision ground to perfect flatness.

Let VOSS make your next Valve Plates and Discs!

J. H. H. VOSS CO., Inc. 785 East 144th Street NEW YORK 54, N. Y.

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 193.)

able, are forced draft, and have the same cooling capacity. Model L has the fan and tube sections mounted vertically, and Model M, horizontally. Dimensions, weights, and rating tables for cooling water are given in Bulletin DC-50. The coolers are designed to operate up to 150 psi. at 300°F.

Agitating and Mixing Equipment

24 A 32-page catalog, "Patterson Agitating and Mixing Equipment," published by The Patterson Foundry & Machine Company, includes Typhoon portable power mixers, agitator-mixer assemblies, the Unipower agitator-mixer drive, outside-packed, side-entering agitators, acid-resistant Porox linings for mixers and other processing tanks and equipment, and other products and services. Specifications and operation and application information are provided.

Tank Insulation

25 Nicholson & Galloway's unique method of tank insulation "which is receiving wide acceptance in the oil industry," is described in a bulletin. Three steps are involved: 1) channel sections of 18-gauge steel are rigidly welded to the walls of the tank or still, 2) the surface of the tank metal is divided into areas bounded vertically by channel sections, and horizontally by shelf angles welded between channels, insulation being installed within these areas; and 3) the insulation then "protected by a cladding of .024 corrugated aluminum sheathing."

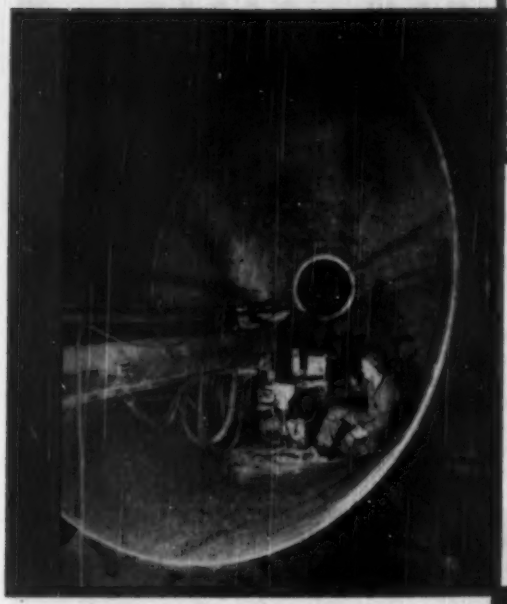
This outer armor "may also be asbestos transite or any of the non-corrosive metals: monel, stainless steel, etc.," it is declared.

Handling Petroleum Products

26 E. W. Saybolt & Company's new 20-page booklet, "Efficient Handling of Petroleum Products," describes regular services provided to the petroleum world by the Saybolt organization and the help that company can provide in the solution of out-of-the-ordinary problems that perplex oil men. Services are directed at more efficient and profitable handling of product both in shipment and storage.

Non-Corrosive Pump

27 Vanton Pump Corporation's "flexi-liner" pump does not permit transferred liquid or gas to touch



Another Example of B&W Research, Engineering, & Facilities

THIS Plus Value IN B&W PROCESS EQUIPMENT

PAYS DIVIDENDS HERE

ILLUSTRATED above is a typical example of the advanced welding practices employed at B&W for the fabrication of pressure vessels. B&W's history of resourceful engineering is distinguished by a 25-year-old succession of developments and improvements in welding machines, automatic controls, techniques, coating of electrodes, inspections, and tests.

B&W's leadership in welding—beginning in 1930 with the first welded boiler drum approved by an engineering authority for high-pressure operation—is being applied to an ever-broadening range of quality-welded vessels for high and low temperatures and pressures, and for corrosive services. Chances are B&W has the economical solution to your process equipment problems. The Babcock & Wilcox Company, 85 Liberty Street, New York 6, N. Y.

BABCOCK & WILCOX

B-401

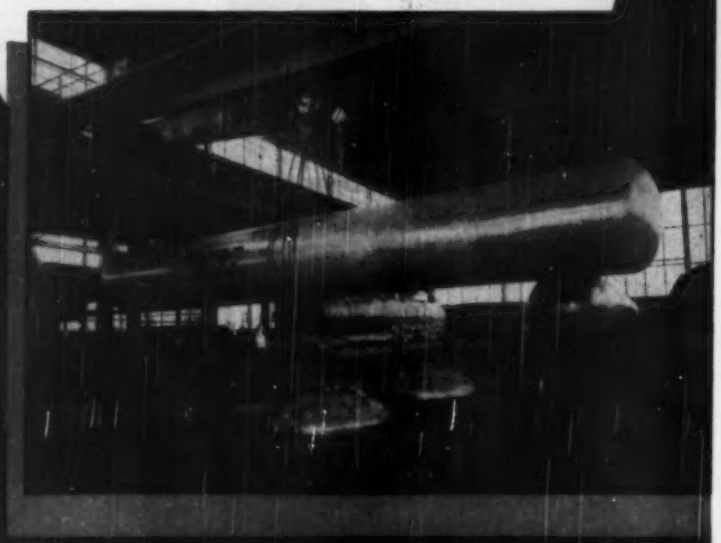
FIND OUT HOW POSEY "stacks up" ON YOUR STACK JOBS

- for GUARANTEED construction
- for price SAVINGS

When your stacks are fabricated at the Posey Iron Works, price isn't "upped" to allow for hesitations in the engineering department . . . false moves in the shop. Since 1910, Posey Iron has constructed steel tanks and stacks in capacities and sizes up to maximum.

Forty years of experience . . . accumulated case histories over the same period . . . permit Posey Iron to design and construct with a sureness that often cuts dollars from the estimate. Stack performance is frequently guaranteed. Posey is equipped to do the complete job . . . from design to fabrication to erection.

It pays to find out how Posey "stacks up" on stack jobs. Write today for free bulletin.



This 50-ton crane (27-foot headroom) allows quick, easy handling of sizeable units like this butane tank. Addition of equipment like this has been a feature of Posey Iron Works production expansion.

Established 1910

POSEY IRON WORKS, INC.

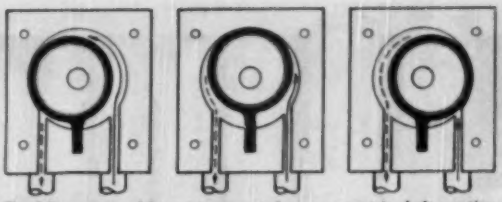
ELEVATED TANKS
STACKS • TANKS
STORAGE TANKS
GENERAL STEEL
PLATE FABRICATION

STEEL PLATE DIVISION
formerly LANCASTER IRON WORKS, INC.

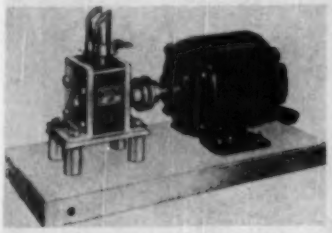
LANCASTER, PA.

DIVISIONS
BRICK MACHINERY
FOUNDRY • INDUSTRIAL
HEATING • IROQUOIS
SHIPBUILDING
STEEL PLATE

any of the metal parts in that the fluid or gas flows on the outside of the "flex-i-liner" and on the inside to the body block. The "flex-i-liner" material can be in either a pure gum rubber or a synthetic rubber, while the body block is of special corrosion and abrasion resistant



Flex-i-liner actuated by a rotor mounted on an eccentric shaft creating a squeegee pressure action and resulting in a positive displacement of the fluid.



bakelite. An eccentric rotor mounted on a ball bearing rides inside and activates the "flex-i-liner." The "squeegee" created is the basis of the pump operation. Five models are available. The pump may be obtained dismounted or mounted and direct-connected to a ¼ hp. a.c. motor operating at 1750 rpm. Special requirements such as variable speed, explosion proof, or totally enclosed motors can be fulfilled. Dimensions of the pump are 3¾ inches by 4½ inches by 2½ inches. Other features are positive displacement and self-priming, elimination of glands, stuffing boxes and check valves.

Liquid Sample Cooler

28 A liquid sample cooler for cooling boiler and boiler feedwater, announced by Worthington Pump and Machinery Corporation, also is suitable for cooling samples required for controlling chemical and refinery processes and for general laboratory use. Of stainless steel construction, it is a shell and tubular coil type heat exchanger of all-welded construction designed so that all connections are external to both cooling coil and jackets. It features the counterflow principle and is designed for 1500 psi. and temperatures of 600°F. on the cooling coil side, and 150 psi. on the stainless jacket side.

pH Electrodes

29 The complete line of Leeds & Northrup pH electrodes and assemblies for both industrial and laboratory applications is presented in a catalog, "pH Electrodes, Assemblies, Parts and Accessories."

This publication is designed to help present users of L&N pH equipment in ordering replacement parts and to guide new or prospective users in selecting the proper electrodes to solve their pH problems.

Water Hardness

30 Simple and accurate new "one-minute tests" for determining water hardness are described in Bulletin 1RE50 issued by Hall Laboratories, Inc. Procedures, reagents and equipment for the new tests are described. Accuracy to within 1 ppm. has been demonstrated. The new tests may be employed to determine total water hardness; hardness due to calcium alone; or hardness due to magnesium alone (this last simply by difference between total-hardness and calcium-hardness results).

Utility Pump

31 A new, general purpose utility pump for removal of water from underground utility installations has been introduced by Kenco, Inc. Of corrosion-resistant bronze construction, it operates completely submerged, con-

This queer-appearing fellow might have stepped out of a movie of another world, but actually he is only one of a trained NATASCO Crew. Protected by specially designed clothes, he sandblasts such surfaces of tanks as require this treatment before NATASCO corrosion prevention products are applied. He is just one of a crew of skilled men, with equipment built for each specific task, who will make money for you by protecting your tanks against corrosion.

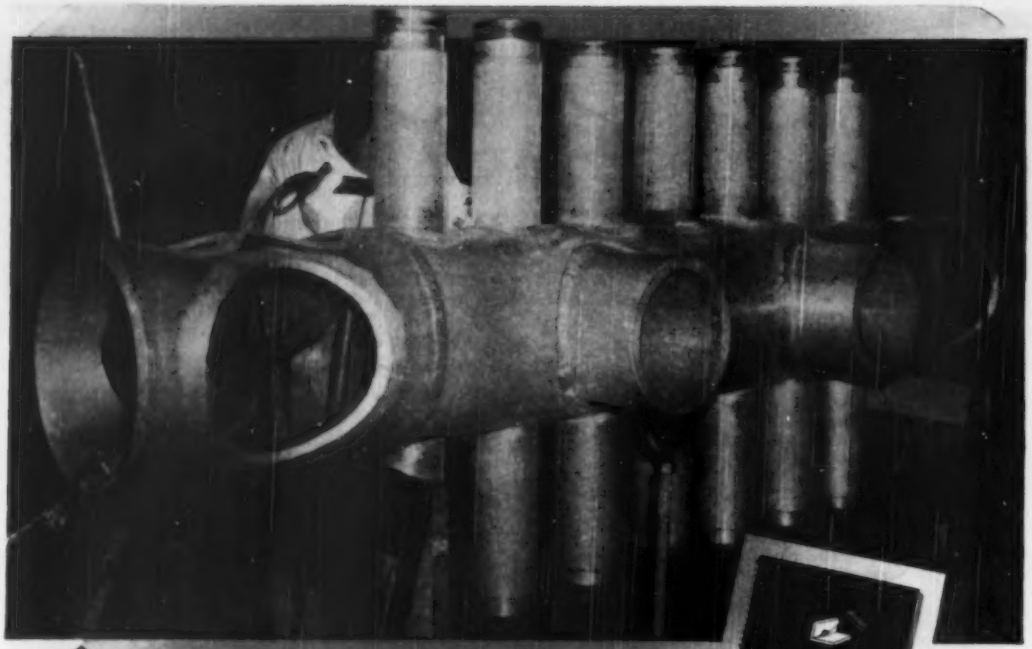
A post card will bring complete information about NATASCO SERVICES

Every NATASCO job is Guaranteed

THE Natasco COMPANY

Lease Tank Service—West Texas Area: Williams Construction Company, Odessa, Texas

California Representative: Coast Contractors, Ltd., 4636 E. Slauson, Maywood, Cal.



133 Pages
52 Illustrations
18 Tables
Complete
Index

Tough to fabricate? Expensive?

Not when you use the methods described in this new Alcoa booklet

Some of the nozzles and laterals on this aluminum header have 1½-inch wall sections. Yet welding was easy with the methods described in this booklet. Joints are tight and smooth. Fabrication costs were low.

And note the simple wooden trestles supporting the assembly . . . dramatic evidence of aluminum's light weight and ease of fabrication.

The equipment shown here is to be used in sub-zero production of oxygen . . . an ideal application for aluminum. For, the lower the temperature the better the performance you get from aluminum. As temperatures drop from 75 degrees F. to minus 320 degrees F., Alcoa 3S alloy gains 23% in yield strength, 80% in elongation, and 67% in tensile strength.

If you want to know more about low-cost fabrication of aluminum, write for a copy of "Welding and Brazing Alcoa Aluminum". You'll find it helpful. And if you are considering design of new equipment in which aluminum might improve performance and lower costs, our engineers will gladly consult with you. Write ALUMINUM COMPANY OF AMERICA, 1476K Gulf Building, Pittsburgh 19, Pa.

ALCOA FIRST IN **ALUMINUM**

ALCOA ALUMINUM ®

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 193.)

trolled by an exclusive liquid-level switch. It may also be operated manually with the through cord switch which makes possible instant operation at any depth of water. The through cord switch can later be snapped to the automatic position, and pump will continue, turning off automatically when it draws air. Water can be drained to within ⅛-inch of the area floor by placing the pump on the floor directly on the strainer screw heads. The liquid-level switch operates through air pressure created when water rises, trapping air within the switch skirt. This pressure moves a diaphragm which trips an Acro snap switch, starting the pump.

Chemical Process Equipment

32 A new line of chemical process equipment, made of synthetic resins and "designed to meet stringent corrosion resistant requirements," has been announced by the General Ceramics and Steatite Corporation. The new equipment, trade named Kemplas, is made of modified phenolic resins developed and produced by the Pennsylvania Salt Manufacturing Company. The resins are either cold cast or laminated with glass cloth and molded into desired shapes. In addition to being highly resistant to many types of corrosion, the new equipment has the further advantage of being very lightweight and yet stronger than many construction materials normally used in such equipment.

Rotary Pump

33 De Laval Steam Turbine Company's A31A IMO rotary pump features pulsation free flow; mechanical shaft seals; pre-lubricated bearings; optional types of mountings; can be mounted in any position and driven by direct connected shaft, V-belt or chain. Capacities are 85 gpm., pressures to 150 psi. A bulletin contains a cross-section drawing, description of the pumping principle, viscosity tables, dimension drawings and table of standard NEMA motor frame sizes.

Multi-Combination Meter

34 A new model, the B-3, of the multi-combination meter for electrolysis, corrosion and cathodic-protection testing, announced by M. C.

NOW New Streamlined

RIDGID 65R

Die Stock that WON'T JAM

while threading with power drive or by hand

New *JAM-PROOF* drive plate automatically kicks out driving ratchet pawl when standard length thread is cut.... You don't have to watch it—lead screw can't jam on workholder.

Right Here is the simple foolproof mechanism that makes 65R automatically *JAM-PROOF.*

You can convert your present 65R to new *JAM-PROOF* type—buy new drive plate, put in place of old plate.

All other RIDGID 65R features remain the same

Perfect threads on 1" to 2" pipe with 1 set of high-speed steel dies—sets to pipe size in 10 seconds—mistake-proof self-centering workholder sets instantly—and now it's *JAM-PROOF.*

Buy new JAM-PROOF RIDGID 65R at your supply house

RIDGID

WORK-SAVER PIPE TOOLS

THE RIDGE TOOL CO. • ELYRIA, OHIO

for IDEAS that

Simplify and Improve Design
•
Better Fabrication
•
Reduce the Cost

ASK FOR

MODERN PIPE WELDING PRACTICES

BY F. C. FANTZ

BULLETIN 49-A

MIDWEST PIPING & SUPPLY CO., INC.

...AULS – NEW YORK – BOSTON – LOS ANGELES – CHICAGO

of Piping Systems

This technical bulletin is a study of ways and means of using welding for the improvement of piping systems. It was written by F. C. Fantz, Vice President, Midwest Piping and Supply Co., Inc., out of many years' experience with welding as applied to all kinds of piping. He has described in detail and illustrated a number of practical, tested methods of obtaining better piping assemblies. Here is a 16-page bulletin full of workable, proven ideas that will be helpful to anyone interested in modern piping systems. Use the coupon below or ask the nearest Midwest plant or office for a copy.

Midwest Piping & Supply Co., Inc.
1450 So. Second St., St. Louis 4, Mo.

Please send me (without obligation) Bulletin 49-A, "Modern Pipe Welding Practices."

NAME_____

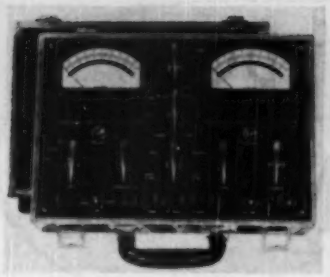
COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

MIDWEST PIPING & SUPPLY CO., Inc.

MAIN OFFICE: 1450 SOUTH SECOND STREET, ST. LOUIS 4, MO.
Plants: St. Louis, Passaic, Los Angeles and Boston • Sales Offices: New York 7—30 Church St. • Chicago 3—79 W. Monroe St. • Los Angeles 33—520 Anderson St. • Houston 2—1213 Capitol Ave. • Tulsa 3—533 Mayo Bldg. • Boston 27—426 First St.



Miller, is small and compact compared with the previous Model 5, although it has a low range of 2 millivolts and special mirror scales 3.9 inches long. By use of circuit selector switch, the two high-sensitivity d-c instruments can be connected into a variety of measuring circuits for measurement of potentials, current, resistance and soil resistivity. Internal batteries with switch and coarse and fine controls can be used to supply and control current for test purposes. Voltmeters, or voltmeter and ammeter can be used separately or simultaneously. Polarity reversing switches are provided for both current and potential measurements.

Heat Exchanger Application

35 The Patterson Foundry & Machine Company has published "Process Applications of Heat Exchangers," a catalog explaining the Patterson standard line of heat transfer equipment, and its application to the petroleum chemical, petrochemical, and process industries. Services available through the process engineering division, are explained. Also included are outlines of various standard heat exchangers and factors to be remembered when setting up a heat transfer operation. Construction details and process applications complete the catalog.

Vacuum Tight Fitting

36 Swagelok fittings made by Crawford Fitting Company are made in a range of sizes for use with tubing ⅛ to 1 inch outside diameter. Two ferrules and the threaded chuck inside the Swagelok's nut, clinch tight around the tubing wall, providing a leakproof seal. Available in brass, monel, aluminum, steel, and stainless steel, the fittings are for use with tubing material of aluminum, brass, copper, steel, stainless steel, and plastic. Fittings are recommended to overcome problems involving pressure, vibration, and torque.

Gauges and Valves

37 A catalog on gauges and valves for the observation of liquids and levels has been published by Jerguson Gage & Valve Company. Illustrations, general information and features of the products are given.

Air Locks and Trip Controls

38 Bulletin, S-31, describing the company's air locks and trip master controls for holding regulating and control valves in position during failure of air supply has been published by The Swarthout Company. The bulletin is printed in two colors and illustrated with photographs, diagrams and line drawings.

Laboratory Aids

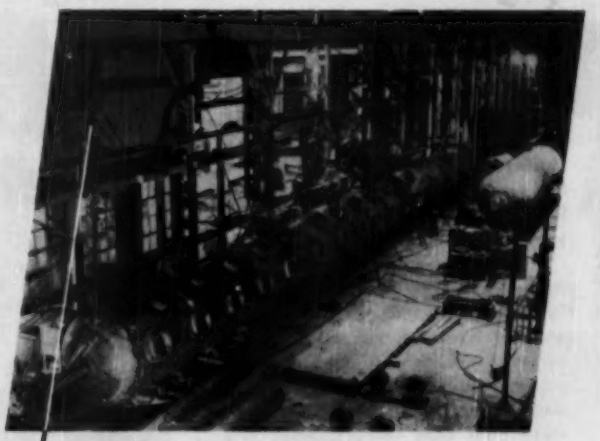
39 "What's New for the Laboratory," released by the Scientific Glass Apparatus Company, Inc., No. 11 in the series, describes a number of new interesting items including a Varicell which eliminates storage batteries, a quadrant culture plate, a flask with special cork insulated top to prevent burns to hands, and a vacuum oven that's heated by radiation. All told, twenty items are described.

Drum Rinser

40 Gilbert & Barker Mfg. Company's internal drum rinser is electrically connected and requires no piping or air lines. Both pressure and vacuum pump gauges enable the operator to maintain a pump pressure of 35 pounds and a wet vacuum of 15 ins.

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 193.)



* Everything

YOU NEED IN REFINERY EQUIPMENT . . .

Our complete facilities and unlimited experience in tank and refinery equipment fabrication are available to solve all of your equipment problems . . . Our long list of satisfied customers include some of the biggest names in the oil industry. Give us an opportunity to talk to you about your requirements.

McNamar Boiler & Tank Co.

REFINERY SALES DIVISION • BOX 868 • TULSA, OKLAHOMA

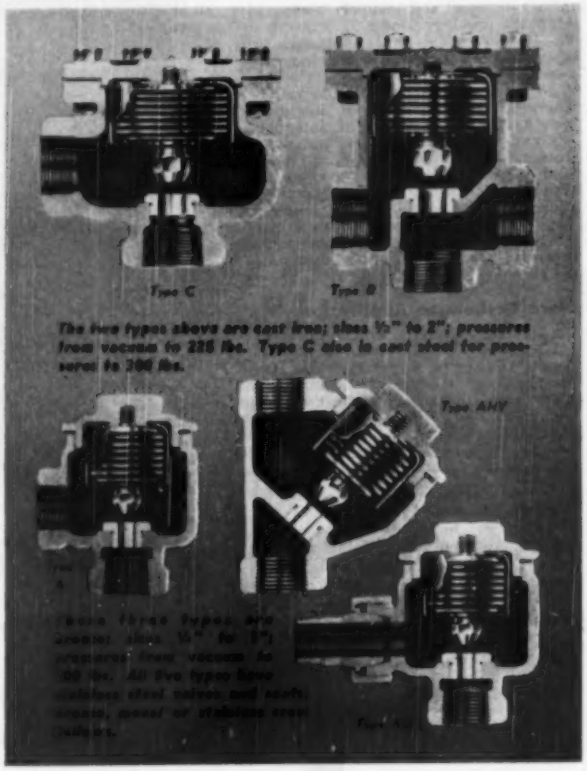
15 OF 20 ENGINEERS PREFER NICHOLSON TRAPS

To determine the best steam trap on which to standardize, a large processing firm recently asked their plant engineers for their preference. In 15 out of 20 plants the choice was Nicholson.

The repeated adoption of Nicholson steam traps in plants currently in big "cost-reduction-through-modernization" programs is another indication of their advanced features. To learn why an increasing number of leading plants are standardizing on Nicholson thermostatic steam traps send for Nicholson catalog 250.

5 TYPES for Every Application

A survey showed these Nicholson features to be the leading reasons for the engineers' preference: 2 to 6 times average drainage capacity; shorter heat-up time. Operate on lower temperature differential; fast action keeps equipment full of live steam. Maximum air-venting capacity. Types for every process, power and heat application.


Type C
Type B
The two types above are cast iron; sizes ½" to 2"; pressures from vacuum to 225 lbs. Type C also in cast steel for pressures to 300 lbs.
Type AHV

SEND FOR
Nicholson Trap Catalog #250

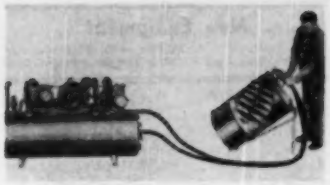
A standard reference on drainage methods; newly revised. Describes traps for all mediums and pressures:—thermostatic and metal expansion for medium pressures; weight and piston operated for heavy duty. 32 pages; complete with capacity tables, installation diagrams, as well as a section containing data, charts and formulae for determining the proper size trap for specific applications.

REPRESENTATIVE APPLICATIONS

Sterilizers	Agitators	Molding Platens	Convectors
Pans	Retorts	Calenders	Pipe Coils
Autoclaves	Cookers	Unit Heaters	Steam Mains
Jacketed Kettles	Water Heaters	Blast Coils	Headers
Tanks	Driers	Stack Heaters	Risers
Vats	Dry Kilns	Radiators	Separators

W. H. NICHOLSON & CO.
207 OREGON ST., WILKES-BARRE, PA.

Sales and Engineering Offices in 53 Principal Cities



during the cleaning operation. The nozzle is designed for rinsing 55-gallon light iron drums, while an adjustable collar makes the nozzle adaptable to other types of 55-gallon drums. In operation, two control valves on the nozzle are opened and the solvent forced into the drum through a series of small holes in the outer nozzle tube; at the same time, the contaminated solvent is being evacuated from the drum through the inner nozzle tube.

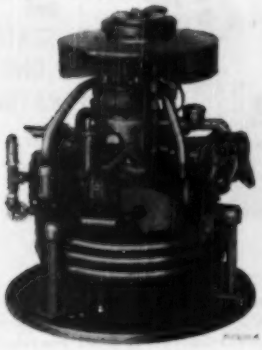
Flow Pumps

41 Data Sheet 64-B of The Aldrich Pump Company describes the new 5-inch stroke multiplex direct flow pumps. Included are advantages, construction, specifications, drive requirements, pump selection chart, dimension drawings, plunger, pressure and capacity data on both the 5 and 7 plunger units. The capacity range of these two pumps, in barrels per day at 100 rpm. is from 292 up to 5060 barrels. Maximum pressures range from 614 psi. with 3½-inch diameter plungers to 7500 psi. with 1-inch diameter plungers.

Flow Regulator

42 A cutaway illustration which explains the operation of the Kates direct acting flow regulator is the principal feature of Bulletin 502, issued by W. A. Kates Company. Specifications are given for regulators from 0.1 to 100 gpm. The regulator is self-contained and entirely independent of air lines, electric current, remote valves or other connected apparatus.

Spot-Air Compressor



43 Driven by a gasoline engine, a new 36-cfm. spot-air compressor introduced by Ingersoll-Rand Company, weighs 265 pounds, and is 32 inches high on a 27-inch diameter baseplate. A special wheelbarrow mounting makes the compressor portable. The fuel tank capacity permits up to 2½ hours continuous operation. A horizontal arrangement of three power cylinders and three air cylinders spaced alternately at 60° intervals around a vertical single-throw crankshaft gives a smooth conversion of engine power into air power without the need of a heavy flywheel. The compressor's rated 36 cfm. is at 80 psi., suitable for operating an Ingersoll-Rand J-10 utility jackhammer or other small air tools on construction and maintenance jobs.

Recording Gauges

44 The Bristol Company's bulletin on its "Series 500" line of recording gauges gives information on pressure gauges for ranges from 0 to 2 inches of water to 0 to 10,000 psi. vacuum gauges, low range draft and pressure gauges, barometers, and absolute pressure gauges for ranges as low as 0 to 6 millimeters of mercury absolute. Measuring elements, operating principles, recording charts and accessories for the various types of recording gauges are described as are Bristol instruments for automatic controlling and telemetering of pressure and vacuum values.

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 193.)

Organic Chemicals

45 The 1951 edition of the booklet, "Physical Properties of Synthetic Organic Chemicals," (Form 6136) issued by Carbide and Carbon Chemicals

Is there a better bulk plant pump?
There is! THE NEW GILBARCO ROTO-PRIME!
No reservoir or relief valves.
No gear reductions; operates at standard motor speed.
Designed for outdoor service without secondary covering.
Mechanical seal for protection against abrasion and freedom from leakage.
Minimum maintenance — motor oil lubricated.
Ball bearing equipped for long wear and efficient operation.
Capacity 50 to 450 g.p.m.
Gilbarco Roto-Prime Pumps are complete units — with base, electric motor, coupling, built-in check valve and mechanical seal.
Gilbarco
ROTO-PRIME
Self-Priming Centrifugal Pumps
GILBERT & BARKER MFG. CO.
WEST SPRINGFIELD, MASS
TORONTO, CANADA

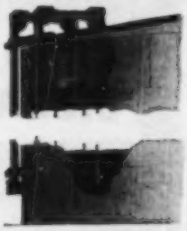
Specify OCECO TANK FITTINGS

FOR EFFICIENT *Fire-Safe* TROUBLE FREE OPERATION

● Although used in all parts of the world—under all kinds of conditions—flame has never entered a tank equipped to Oceco specifications. Get Oceco's proven, dependable protection for your tanks too. It costs only a fraction of one percent of the value of the tank and its contents. Send for the Oceco data sheets. They give complete details. *Write today.*

TYPE "E" FLAME ARRESTORS can withstand long exposure to fire. The "banks" have vertical straight through passages — *minimizing* entrainment and pressure drop, and are "extensible" for easy cleaning. 2" to 10" sizes.

TYPE "BE" VENT UNITS consist of a V-113 Vent Valve with muffler, mounted on a Type "E" "Extensible" Bank Flame Arrestor. 2" to 10" sizes. Unsurpassed for efficiency and reliability.



LIQUID LEVEL INDICATORS AND GAUGES — wide variety of types for roof or on the ground readings of cone, umbrella, floating, or expansion roof and spheroid tanks. Pressures ranging from 0 to 125 lbs. per sq. in.

V-108 EMERGENCY PRESSURE RELIEF VENTS provide instant relief for excessive internal pressures, resulting from exposure fires, etc. Furnished in 6", 8", 10", 15½" and 20½" sizes.

WATER DRAW-OFF VALVES for drawing water from the bottom of storage tanks. Unique double valve construction permits the valve chamber to be drained to prevent freezing, and the working valve serviced without emptying tank. 2"x1¼"; 3" x 2" and 4" x 3" sizes.

V-114 INTERNAL TANK VALVES are provided with a fusible link that melts when subjected to fire, closing the valve instantly, and cutting off the flow. 3", 4", 6", 8", 10", 12" and 16" sizes.

Please note the new address:

OCECO

Engineering and Sales Representatives in the Principal Cities

THE JOHNSTON & JENNINGS CO.

4700 West Division Street • Chicago 51, Illinois

★ *division of* PETTIBONE MULLIKEN CORPORATION ★

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 193.)

Division, Union Carbide and Carbon Corporation, is a condensed guide for users of organic chemicals, presenting data on applications and physical properties of more than 250 synthetic organic chemicals in tabular form for ready and easy reference. Free.

Vertical Turbine Pump

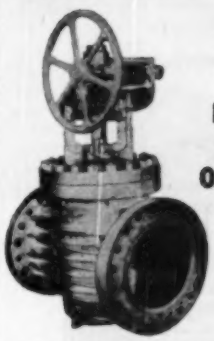
46 A new bulletin by Layne & Bowler, Inc., titled "Layne Short Coupled Service Pumps," contains cut-away drawings of pump bowls and discharge column. Sketches show the Layne vertical turbine pump applied to river and re-lift service, boosting, recirculation, cooling tower, drainage, gas and oil pumping, and fire pumps.

Switchboard Instruments

47 A new line of 4½-inch, long-scale switchboard instruments employ a protruding convex-type glass cover that permits the scale to be mounted flush with the front of the instrument case, while providing clearance for moving parts. This cover design eliminates scale shadows from overhead lighting caused by cover overhang. The new "18" instruments are designed for general switchboard service on both large and small equipment where space is limited. Twenty-five of the new instruments can be mounted on a panel 24 inches square. Magnetic damping as-

WEDGEPLUG

ALL-PURPOSE STEEL VALVES



LIFTS TURNS and RE-SEATS IN ONE OPERATION

☆

DRY PLUG

☆

PRICED to compete with conventional plug-type valves. Interchangeable with American Standard Steel Wedge Gate Valves. Wrench-Operated; Direct Handwheel-Operated; Worm Gear-Operated; Sizes from 1" to 16". Write for our Catalog No. 600 and Price List. On request, we will be glad to quote on larger sizes above 16".

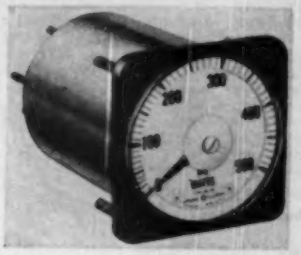
WEDGEPLUG VALVE CO., INC.

Department "R"

NEW ORLEANS 15, U. S. A.

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 195.)



sures quick response and permanency of characteristics. Designated as types AB-18 (a-c) and DB-18 (d-c), the new instruments are mechanically interchangeable with the established line of General Electric Company's long-scale instruments, Types AB-DB-15. Models include d-c ammeters and voltmeters and a-c ammeters, voltmeters, wattmeters, frequency meters, power-factor meters and synchroscopes.

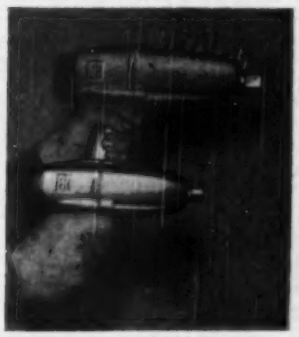
Centrifuges

48 Bulletin 1259, prepared for industries requiring the application of centrifugal force to perform the functions of separation and clarification of liquids; and removal, recovery and classification of solids is announced by The Sharples Corporation. Both tubular bowl and disc type centrifuges, together with the horizontal bowl decanter type and crystal dehydrator are summarized.

Aluminum Rolling Scaffolds

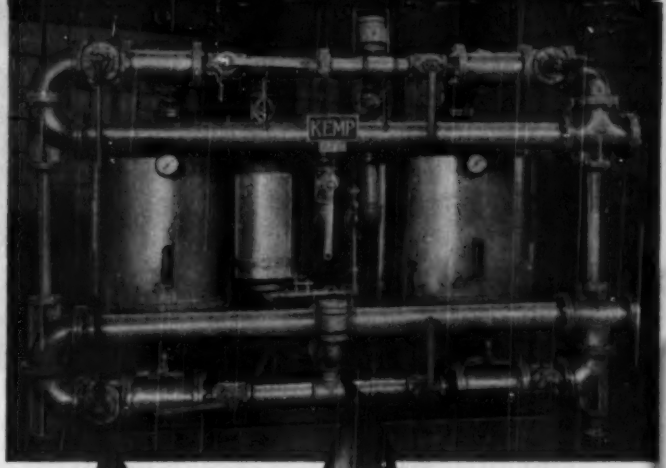
49 A bulletin on aluminum sectional rolling scaffolds issued by Patent Scaffolding Company, Inc., includes photographs of scaffolds in actual use, with specifications, as well as descriptions of the pre-fabricated construction and uses of this type of scaffolding.

Nut Running Tools



50 Ingersoll-Rand Company announces two new air operated impactools, the size 504 for nut running up to ⅜-inch bolt size, and the size 510 for nut running up to ¾-inch. Both tools are of the pistol grip type and have deeply grooved handles for sure hold. Size 504 weighs 5¾ pounds and is 8 9/16 inches long. The 504 may also be used for multipurpose operation in

STOP MOISTURE DAMAGE



Kemp Dynamic Dryers solve moisture control problems—combine dependable operation with low operating cost!

YES, no two ways about it, Kemp Dynamic Dryers *control moisture* at rock bottom prices. For example, a Kemp unit drying gas may cost you as little as ¼ *cent per mcf!* And that ¼ of a cent includes *all* labor and utility costs—plus the cost of the equipment amortized over a five-year period! But low operation cost is just part of the Kemp story.

SIMPLE OPERATION

Kemp Dynamic Dryers are flexible . . . offer *manual, semi-automatic* or *automatic* operation. Desiccant is especially selected and compounded for the particular duty. Units are available for drying *air, gases* or *liquids* . . . for controlling humidity in large or small areas. Choose gas, electric or steam regeneration . . . with or without cooling units.

GUARANTEED PERFORMANCE

No matter what your moisture control problem may be . . . specify Kemp first. Chances are there is a standard design that will be ideal for your plant . . . and at the same time save you money! Performance to your specifications is guaranteed! For full information mail coupon for special bulletin.

KEMP OF BALTIMORE — **DYNAMIC DRYERS**

CARBURETORS
BURNERS
FIRE CHECKS
ATMOSPHERE & INERT GAS GENERATORS
ADSORPTIVE DRYERS
METAL MELTING UNITS
SINGEING EQUIPMENT
SPECIAL EQUIPMENT

THE C. M. KEMP MFG. CO., Dept. K-10
405 E. Oliver St., Baltimore 2, Md.

Gentlemen: Please send me Information Bulletin D-27. We want the facts on drying ☐ air ☐ gas ☐ liquids.

Name .....
Company .....
Address .....
City ..... Zone ..... State .....

BLAW-KNOX FOG SYSTEMS

STOP THESE FIRES BEFORE THEY START!

Deluge Systems, Wet Pipe Systems, Dry Pipe Systems, Water Spray and Fog Systems, Rate-of-Rise Sprinkler Systems, and Foam and Carbon Dioxide Extinguisher Systems.

"LITTLE JOEY SPRINKLER"

Storage of oil or volatile liquids presents special fire hazards. Blaw-Knox Fog Nozzles and thermostatically controlled Fire Protection Systems give no handicaps to fire—no chance for fire to get out of control. The "double-purpose fire-plus" spray instantly spreads a cloud of wet fog and at the same time strikes through to the base of any fire.

A survey of your fire hazards to determine which system will give you the utmost protection at the least cost involves no obligation.

Blaw-Knox Fire Protection Systems carry the approval of all insurance underwriters.

BLAW-KNOX SPRINKLER DIVISION
OF BLAW-KNOX CONSTRUCTION COMPANY
829 Beaver Ave., N.S., Pittsburgh 12, Pa.
Offices in Principal Cities

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 193.)

drilling up to ¼-inch diameter, or step drilling to ¾-inch, reaming up to 9/16-inch diameter, tapping up to ⅝-inch diameter, driving screws up to ⅜-inch machine or number 20 wood. It also is suited for hole sawing in sheet metal, broken stud and cap screw removal, and driving and removing studs, etc. The 510 weighs 11¼ pounds and measures 10⅞ inches long.

Meter Adapter

51 An adapter for installing "flow-rator" meters in horizontal process piping has been announced by Fischer & Porter Company. This adapter eliminates the necessity for a vertical rise in a line where head room is at a premium. The horizontal line adaptor is constructed of a number of corrosion-resistant materials, and may be supplied for use with all standard meters. Eye-level flow indication for accurate instrument reading, is now made possible by this adapter, where necessity of vertical runs made it impossible before.

Publisher's Statement

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 OF PETROLEUM REFINER, published monthly at Houston, Texas, for October 1, 1950.

State of Texas, County of Harris, ss:

Before me, a Notary Public in and for the State and county aforesaid, personally appeared A. L. Burns, who, having been duly sworn according to law, deposes and says that he is the Business Manager of PETROLEUM REFINER and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily, weekly, semiweekly or tri-weekly newspaper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the act of August 24, 1912, as amended by the acts of March 3, 1933, and July 2, 1946 (section 537, Postal Laws and Regulations), printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Ray L. Dudley, 3371 Chevy Chase, Houston, Texas; Editor, Lindlow S. Dandale, 1513 Chippendale, Houston, Texas; Managing Editor, Silas B. Ragsdale, 1636 North Blvd., Houston, Texas. Business manager, A. L. Burns, No. 7 Chelsea Place, Houston, Texas.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

The Gulf Publishing Company, Houston, Texas; James Anderson, Houston, Texas; A. L. Burns, Houston, Texas; J. F. Carter, Jr., Tulsa, Okla.; Mrs. Mary Margaret Cashman, Houston, Texas; Mrs. Carolyn Dodson Dudley, San Angelo, Texas; June Wooden Dudley Bliss, Trustee for Miss Fredrica Lucinda Dudley, Houston, Texas; Ray L. Dudley, Independent Executor and Trustee of Estate of Ida. N. L. Dudley, Deceased, Houston, Texas; Ray L. Dudley, Houston, Texas; Wm. G. Dudley, Houston, Texas; Mrs. Libbie Rice Farish, Houston, Texas; Wm. V. Gross, Utopia, Texas; Mrs. Anita R. Lane, Houston, Texas; Chas. H. Lane, Houston, Texas; Tom W. Nelson, Houston, Texas; Mrs. Maude G. Sterling, Houston, Texas; O. K. Waller, Chicago, Ill.

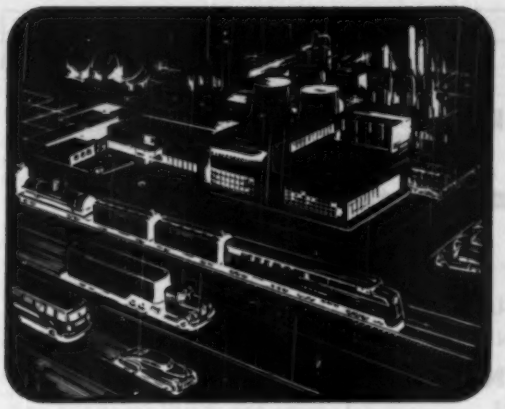
3. That the known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: M. D. Anderson Foundation, Houston, Texas.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has not reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

A. L. BURNS, Business Manager.

Sworn to and subscribed before me this 13th day of August, 1950.

P. J. AUCOIN.
(Seal) Notary Public in and for Harris County, Texas.
(My commission expires June 1, 1951)



IT ISN'T A QUESTION OF LEADERSHIP

Leadership in any field is a wonderful tribute to a fine product. But the Layne organization is anxious to have all prospective buyers consider the genuine quality of their Well Water Systems. Layne wants people to remember that their years and years of world-wide experience is being used to build better and better water systems; to find and remove even the smallest imperfection; to create, test and use new ideas that step up efficiency without adding cost.

Wherever you go, you will see Layne Well Water Systems serving cities, factories and all kinds of important industrial and chemical plants. In every case the buyer has carefully measured quality and efficiency against the investment and then decided that Layne and Layne alone could fulfill his needs.

A poor well is a bad investment. A good one saves many dollars each year. You can call in Layne and then contract for the complete job; survey, test drilling, drilling of the well, setting casing and sand screen, building and installing the pumps and final testing—all by well trained men of the Layne organization. No divided responsibility.

For further information, catalogs, etc., address

LAYNE & BOWLER, INC.
General Offices, Memphis 8, Tenn.

LAYNE

WELL WATER SYSTEMS

VERTICAL *Turbine* PUMPS

ASSOCIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. • Layne-Atlantic Co., Norfolk, Va. • Layne-Central Co., Memphis, Tenn. • Layne-Northern Co., Mishawaka, Ind. • Layne-Louisiana Co., Lake Charles, La. • Louisiana Well Co., Monroe, La. • Layne-New York Co., New York City • Layne-Northwest Co., Milwaukee, Wis. • Layne-Ohio Co., Columbus, Ohio • Layne-Pacific, Inc., Seattle, Washington • The Layne-Texas Co., Ltd., Houston, Texas • Layne-Western Co., Kansas City, Mo. • Layne-Minnesota Co., Minneapolis, Minn. • International Water Corporation, Pittsburgh, Pa. • International Water Supply, Ltd., London, Ont. • Layne-Nispano Americana, S. A., Mexico, D. F. • General Filter Company, Ames, Iowa

are your

- STILLS
- DRYERS
- EVAPORATORS
- CRYSTALLIZERS
- PROCESS VESSELS

OPERATING AT VACUUMS LIMITED BY THE VAPOR PRESSURE OF THE CONDENSATE?

Many stills, dryers, evaporators, crystallizers and other processing vessels are operating at vacua limited by the vapor pressure of the condensate. This means on the average an absolute pressure of about 2.0" Hg. Most owners of such equipment do not realize how practical and economical it is to put a Booster Evactor in the line between the vessel and the condenser and maintain an absolute pressure of 0.5", 0.25" or even lower. The benefits of this higher vacuum in improving quality and capacity are often very substantial.

The steam jet type of vacuum pump has continually gained in favor for high vacuum in industrial process work. The total absence of moving parts is a big advantage and means many years of service, with no maintenance cost. Available in single, two-, three-, four- and five-stage units for vacuum from a few inches up to a small fraction of 1 m.m. Hg. absolute.

Croll-Reynolds have been specializing on this type of equipment for over 30 years, and have made thousands of separate installations. Their engineers have extensive experience in applying it to numerous different processes, and are available for consultation without obligation. Literature is also available on request.

C-R REYNOLDS

CROLL-REYNOLDS CO., INC.

17 JOHN STREET, NEW YORK 7, N. Y.

Chill-Vactors Steam Jet Evactors Condensing Equipment

The Newest Expander

TYPE "FC"
WITH FRICTIONLESS COLLAR

BY THE OLDEST
ORIGINAL MANUFACTURER
OF TUBE EXPANDERS

FOR AUTOMATIC CONTROL UNITS
OR OTHER GENERAL PURPOSE DRIVES

Features Ball Bearing Thrust Collar To Eliminate Marring And Friction On Tube End Produced By Thrust of Expander.

A. L. HENDERER'S SONS

620 MARYLAND AVENUE
WILMINGTON, DELAWARE

Write for Bulletin 80-130

it's made of stainless steel
to the most rigid specifications

PRESSURE SAMPLE CONTAINERS

ICC Approved
Invaluable for sampling liquids and gases

At last here are the Hoke Pressure Sample Containers standard pressure vessels made of stainless steel to the most rigid specifications.

This new Hoke product is proving invaluable for sampling of both liquids and gases. They are ICC approved and available in two standard service pressure ranges, namely: 400 psi and 1800 psi. Either double or single valving is obtainable. 18-8 Stainless Steel is standard material. Other metals, ferrous or non-ferrous, manufactured on special order.

Write for Folder P10 giving details and prices

OK
Hoke Incorporated
ENGLEWOOD, N. J.

BOOKS

API Guide to the Inspection Of Fire Protection Equipment

Recommended Practices for Refinery Inspections, Part III — Fire-Protection Equipment, American Petroleum Institute, 50 West 50th Street, New York 20, $1.00.

An occasional breakdown in fire prevention is inevitable. Loss of life and property can be kept at a minimum only if protection equipment is in good working condition. This can be accomplished by proper inspection on maintenance.

As a guide to such inspection, this manual should be used to supplement local laws and regulations.

Included in the equipment discussed are fire pumps and pump houses, firewater line systems, chemical extinguisher systems, first-aid fire extinguishers, hose and hose houses, automatic devices, fire alarm systems, and drainage.

The appendix contains 30 pages of typical inspection reports.

Petroleum Engineers Explain Carthage, Texas, Gas Field

Petroleum-Engineering Study of the Carthage Gas Field, Panola County, Texas, Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13. Free.

A petroleum-engineering study describes the extensive Carthage gas field in Panola County, Texas, considered the fourth largest natural gas reserve in the U. S. At the time of the study, the pipe line outlet capacity of the field was about one billion cubic feet of gas per day and five natural-gasoline plants and one cycling plant were operating with a total processing capacity of about 350 million cubic feet of gas per day. Since the survey, both natural-gasoline plant capacity and pipe line outlet capacity have been increased.

Report of Investigations 4698, which includes descriptions of the geology of the field and producing reservoirs, drilling and development of the field, gathering systems and pipeline outlets, natural-gasoline plants, and estimates of gas reserves, was prepared by C. J. Wilhelm, principal petroleum engineer; H. M. Harris, associate petroleum engineer; and M. N. Harlin, former petroleum engineer (deceased), of the Bureau's petroleum experiment station, Bartlesville, Okla.

Chemical Engineering Economics

Chemical Engineering Cost Estimation, Robert S. Aries and Robert D. Newton, Chemonomics, Inc., 400 Madison Avenue, New York 17, $5.00.

There has been little information available in the chemical literature on the economic side, few data for making sound business analyses of projected processes and plants. This book takes a long step forward. It correlates the published data on equipment costs and gives at least indicative figures for many of the other elements of economic appraisal.

It allows estimating of equipment costs by graphical methods for all pieces of major equipment, piping, insulation

Federated first for Lead Products

Asarco Sheet Lead... All commercial weights and sizes. Chemical...Tellurium Chemical...Antimonial.

Asarco Lead Pipe... All commercial sizes. Special sizes on request. Chemical...Tellurium Chemical...Antimonial.

Asarco Lead and Lead Lined Valves
... Split Type "Y" and "Angle", Standard "Y", Gate, Check, Hard Lead "Y", Plug and Seat.

Asarco Lead Fittings... Elbows, Crosses, Tees, "Y's", (with plain ends, with flanges on, or for flanging in the field). Chemical and Antimonial.

Asarco Lead Wool... 5/8" rope in 50 lb. waterproof bags.

Asarco Lead Specialties... Extrusions and Castings to specification.

See Federated also for Lead Lined Pipe Lead Lined Fittings, Lead Lined Flanges

Federated Metals Division
AMERICAN SMELTING AND REFINING COMPANY,
120 BROADWAY, NEW YORK 5, N. Y.

Pump Packing Troubles

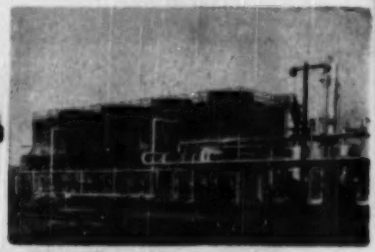
may mean costly shutdowns. Packing troubles ALWAYS mean higher operating costs. Have you tried Centrifugal Pumps which require NO packing? Most satisfactory for pumping acid and other corrosive liquids.

Descriptive Bulletin on Request

THE EDWARD SOPH CO.

Houston 2, Texas
726A M&M Bldg.
Phone Charter 4-8189

Tulsa 5, Okla.
202 E. 18th St.
Phone 3-6659



with Pritchard

INDUSTRIAL COOLING TOWERS

Wherever you see a Pritchard Cooling Tower, you see water conservation at work! In dissipating heat to the atmosphere, Pritchard Cooling Towers assure you greater efficiency and economy... *plus water savings up to 99% over former wasteful methods.*

Pritchard Towers are adequately sized, thoroughly engineered, constructed of highest quality materials...and guaranteed to meet your peak as well as normal load requirements. For the solution to your water conservation problem, consult your nearby Pritchard representative.

WRITE FOR *FREE* BULLETINS

EQUIPMENT DIVISION
J.F. Pritchard & Co.
Dept. No. 81 908 Grand Ave., Kansas City 6, Mo.

District Offices: Houston • St. Louis • Chicago • Pittsburgh • Tulsa • New York
Representatives in Principal Cities

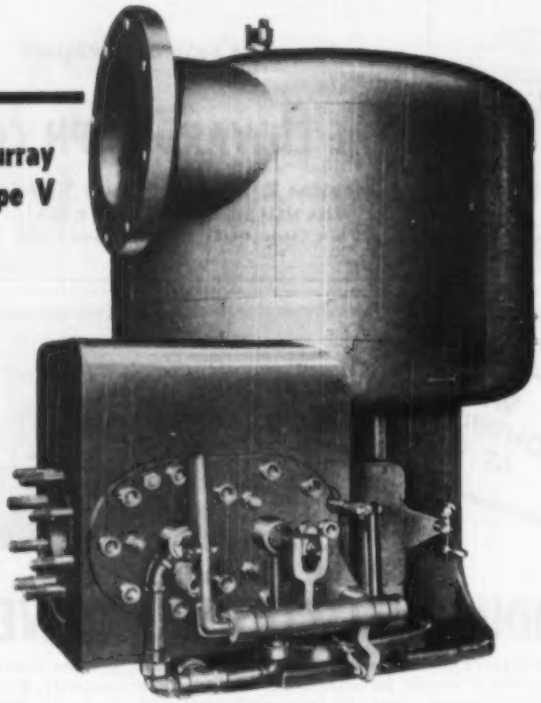
WHY NOT TURBINE DRIVE?

Pumps, fans, compressors, special processing machines, in fact almost any machine requiring driving power can be fitted with an economical and dependable steam turbine driver selected from the many types available.

Steam turbines provide safety, low maintenance expense and ability to operate for long periods without inspection. Unsheltered installations are highly practical.

A large selection of types and frame sizes, special features and accessories are available on short delivery to suit your application.

Murray Type V



Among the newest in the Murray turbine line is the Type V vertical turbine, above. This machine provides completely enclosed construction, either direct-connected or geared for vertical pumps up to 600 HP and beyond. See that your new vertical pump is driven with a Type V steam turbine.

Contact your nearest Murray representative or write direct to—

MURRAY IRON WORKS COMPANY
BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century.

Books

and other auxiliaries. Significant ratios are presented to yield estimates of profit for management appraisal of new projects.

The 100 pages are amply documented with cost tables and with 67 graphs.

Shale-Oil Wax Research

Waxes from Shale-Oil Wax Distillate, Bureau of Mines, Publications, Distribution Section, 4800 Forbes Street, Pittsburgh 13. Free.

Future market demands for paraffin waxes made from petroleum can be partly met by waxes processed from oil shale mined from large reserves in Colorado, Wyoming and Utah, according to Bureau of Mines report of Investigations 4708. Fully refined shale-oil wax is virtually identical with the fully refined petroleum variety and could be used in the manufacture of food containers, the report states. The cost of making the crude and semirefined grades would be about the same as in making petroleum paraffin wax, while the cost of making a fully refined shale-oil wax would be somewhat greater than for fully refined petroleum paraffin, the publication estimates. The report, which describes methods used in extracting, refining, analyzing and testing, and lists the physical properties of the waxes, was prepared by P. R. Tisot and Joseph W. Horne, chemists at the Bureau's petroleum and oil-shale experiment station at Laramie, Wyo.

Story of California Oil

Black Bonanza, Frank J. Taylor and Earl M. Welty, McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, $4.

Oil in the West as revealed in a study of the Union Oil Company of California was selected as a fair cross-section of the petroleum industry as a whole by the authors of this historical narrative.

Among the pioneers of Pennsylvania's petroleum boom in the sixties was Lyman Stewart, who later helped found California's oil industry, and who lived to see petroleum become the lifeblood of the modern world.

"Black Bonanza" is illustrated with 186 photographs.

Reprint Policy

A change has been made in PETROLEUM REFINER's policy with regard to small, individual orders for reprints of its articles. Since January 1 a charge of 50 cents per copy has been made WHEN REPRINTS ARE AVAILABLE. This will continue.

The charge for tear sheets of a particular article, effective April 1, has been reduced to 25 cents.

Cash or company requisitions should accompany all such individual orders.

This change does not affect the price for quantity orders of reprints (starting at 100 copies) which will be quoted upon request.

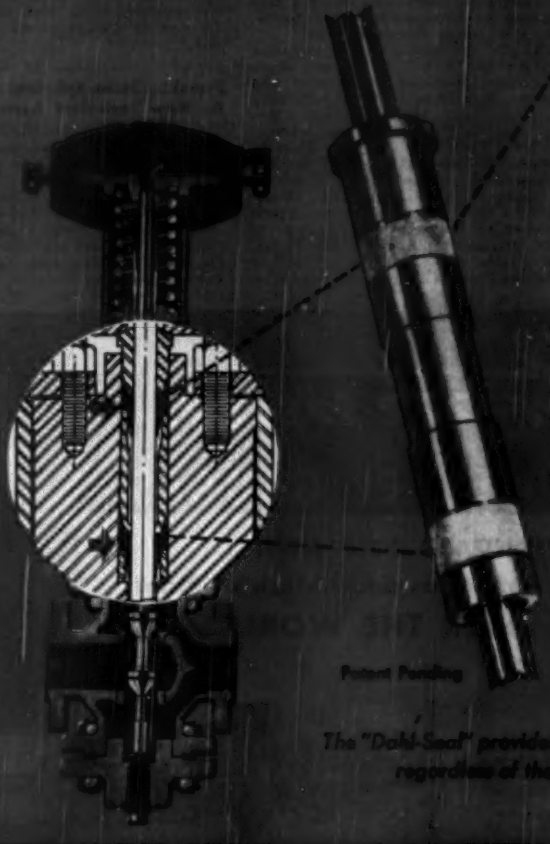
AUTOMATIC CONTROL EQUIPMENT

ENGINEERED DESIGN BY **HAMMEL-DAHL**

The "DAHL-SEAL"®

Eliminates Packing Box and its problems.

No more leakage, friction, periodic take-up, adjustment, lubrication or replacements.



1. The valve stem can be positioned to an accuracy of 0.001" up to the working pressure for which the Valve Body is rated.
2. Eliminates conventional packing box leakage.
3. No periodic take-up or adjustment is necessary.
4. Seals by force of system pressure.
5. Negligible stem friction at any pressure.
6. Completely resistant to chemical attack.
7. Can be used for any temperature for which the valve is designed.
8. Available for any Hammel-Dahl Valve, including those now in service.

Patent Pending

ANOTHER *Hammel-Dahl* FIRST

The "Dahl-Seal" provides a frictionless, leak-proof Valve stem, regardless of the static pressure in the system.

HAMMEL-DAHL COMPANY

243 RICHMOND STREET, PROVIDENCE 3, R. I., U.S.A.

ALBANY BOSTON BUFFALO CHICAGO CINCINNATI CLEVELAND [illegible]
HOUSTON KINGSPORT, TENN. LOS ANGELES NEW YORK PITTSBURGH SAN FRANCISCO
SEATTLE ST. LOUIS SYRACUSE TOLEDO TULSA WILMINGTON, DEL.

In Canada: Railway & Power Engineering Corporation, Ltd.

About EQUIPMENT and SERVICE Suppliers

Is Named Research Director of Taylor Instrument Companies

William I. Caldwell, member of the Research Department of Taylor Instrument Companies since 1937, has been appointed director of research. Nathaniel B. Nichols, his predecessor, will become professor of electrical engineering at the University of Minnesota.

Caldwell

Caldwell took his A.B. in Physics from Indiana University in 1929. He then joined the staff of Purdue University as an instructor in Physics. During this seven-year period he also did graduate work, including research on electron diffraction.

Since going with Taylor, Caldwell's work has been concerned largely with Bourdon springs, and the introduction of a 1200° F. mercury tube system by the company was made possible largely through his work. Recently he has been devoting most of his time to automatic control theory.

Ohio Injector Establishes Five Major Sales Divisions

In a move to integrate sales services at the distributor and customer levels, Ohio Injector Company, Wadsworth, Ohio, has established five major sales divisions, each functioning under a field manager who reports to H. G. Smith, vice president in charge of sales.

The new divisions and the respective managers are New York division (New York City, southern Connecticut and northern New Jersey), Daniel J. Mooney Jr., New York; Atlantic division (Mobile, Ala., to Portland, Maine, excepting New York division area), Paul E. Warner, Philadelphia; Central division (Minneapolis to Buffalo, St. Louis to Pittsburgh), W. G. Shepard, Wadsworth, Ohio; Mid-Continent division (Denver to Kansas City, El Paso to New Orleans), A. A. Kruse Jr., Dallas; and Pacific division (Los Angeles to Seattle), Denny Gordon, San Francisco.

Johnston Pump Elects Brown And Lundie Vice Presidents

Johnston Pump Company has elected Kenneth G. Lundie vice president in charge of sales, and Perry Brown vice president in charge of engineering.

Brown

Lundie

Brown has been chief engineer and Lundie has been sales manager with the company. Both men have been in the vertical turbine pump industry for many years.

Danskin Joins Lubrizol As New Technical Assistant

Kenneth A. Danskin has joined Lubrizol Corporation of Cleveland as technical assistant to the vice president in charge of manufacturing.

Danskin comes to Cleveland from New York, where he had been a staff member of The Texas Company's technical and research division since 1944. He was associated with Texaco for 18 years, serving in research and produc-

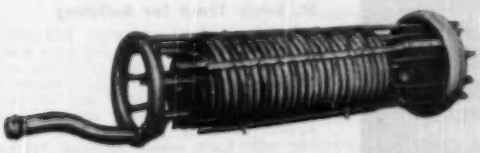
WHERE CAN I GET A DIRECT-EXPANSION GASOLINE COOLER FOR OPERATION AT MINUS 69°F. AND WITH DESIGN PRESSURES OF 1200 P.S.I. ON THE GASOLINE SIDE AND 150 P.S.I. ON THE REFRIGERANT SIDE?

MAKE SURE . . .

LET WHITLOCK MAKE IT!

Here's a problem that's typical at Whitlock. This unit cools gasoline to –69°F. . . . permits aeronautical engineers to study the behaviour of gasoline at high altitude temperatures. The design of the cooler provides even distribution of the Freon 22 refrigerant; the cooling coil being fed from a multiport valve through 9 inlet terminals. The specifications all added up to this storage-type cooler, 18" diam. by 79" long. It was fabricated of Type 347 stainless steel, A.S.M.E. Spec. SA-240 Grade C, and constructed in accordance with Paragraphs U-68, U-140 and Case No. 897 of the A.S.M.E. Code. The assembly was stress relieved and X-rayed as required by these paragraphs.

Whether your heat transfer requirements are standard or "special", ask Whitlock engineers to make recommendations.



THE WHITLOCK MANUFACTURING COMPANY

73 South St., Elmwood, Hartford 10, Conn.

New York • Chicago • Boston • Philadelphia • Detroit • Richmond

In Canada: Darling Bros., Ltd., Montreal

WHITLOCK

SPEED TUBE MAINTENANCE

. . . with the WILSON-DUDGEON Model 50 Refinery Expander

YOU CAN BE SURE of fast easy rolling and solid seating of furnace, still and other heavy wall tubes with the specially designed self-feeding and parallel rolling Wilson-Dudgeon Refinery Expander. These expanders are available in multi-roll types, with and without flare rolls, thrust collars and "ironing-out" attachments. There is a Wilson-Dudgeon Expander available for any type of refinery fitting.

Model 50 Refinery Expander

. . . with the WILSON EP Series Air Motor and Model R Cutter Head

Wilson EP Series Air Motor with Model R Cutter Head

YOU CAN PUT refinery equipment back "on the line" faster with the Wilson EP Series Air Motor and Model R Cutter Head. Size-for-size, the Wilson "EP" can develop up to 40% more power than ordinary motors. This extra power permits faster cutting action to remove hard heavy deposits in a hurry . . . even from tubes with large diameters. The "R" Cutter Head has renewable cutter pin bearings . . . works at faster cutting speeds . . . is self-feeding and non-tracking.

WRITE TODAY—or see your Wilson representative—for complete information on this time-saving, economical tube maintenance equipment. Ask for Bulletin 380 on Tube Expanders, 47A on Tube Cleaners.

THOMAS C. WILSON, INC.

21-11 44th AVENUE, LONG ISLAND CITY 1, N. Y.

CABLE: TUBECLEAN, New York

YW-720

WILSON

WILSON TUBE CLEANERS

WILSON-DUDGEON TUBE EXPANDERS AND SPECIALTIES

tion capacities at their refineries at Lawrenceville, Ill., and Port Arthur, Texas, before going to New York.

Danskin, a graduate of Illinois College at Jacksonville, is a member of the American Chemical Society and American Oil Chemists' Society.

New VAREC Representative Appointed for Houston and Area

Specialties Sales & Service Company, 858A M & M Building, Houston, has been appointed exclusive sales representative for The Vapor Recovery System Company's equipment for the Gulf Coast area. John L. Shaunty is in charge of the new company which replaces VAREC's former factory office in Houston.

John Diehl Elected President Of American Meter Company

American Meter Company has elected John C. Diehl as president. Diehl was born in New Oxford, Penn., and educated at Gettysbury College and Massachusetts Institute of Technology. He was employed by Pennsylvania Railroad until World War I. In 1919 he joined American Meter and was elected Chief Engineer in 1929. In 1934 he was made vice president.

Diehl is a member of the American Gas Association and Gas Appliance Manufacturers Association, and is the author of numerous technical articles and books. Three of his books are "Measurements of Gases," "Natural Gas Handbook," and "Natural Gas Measurements."

Norton McKean, president of the company since 1941, has resigned because of his health.

Hazzard Joins M. N. Aitken Sales Engineering Staff

M. N. Aitken Gas, Oil & Chemical Equipment Company of Houston has announced the addition of a new sales engineer, Robert P. Hazzard, who will sell Robinson orifice fittings and Barton differential flow instruments.

Hazzard

Hazzard has had many years experience with Girdler Corporation handling instrumentation, design and operation of pilot plants. He is a graduate of Drexel Institute in Philadelphia, receiving his degree in chemical engineering from that school in 1929.

Milton Dewey to Canadian Company's Research, Sales

Milton A. Dewey, who has served the Du Pont Company for 13 years in petroleum chemicals research and sales, has resigned to head a newly created tetraethyl lead sales department in Canadian Industries Limited, chemical manufacturing distributing concern. The department under Dewey will be responsible for Canadian sales of Du Pont tetraethyl lead antiknock compounds and the company's other petroleum additives.

Dewey

Dewey's headquarters will be in Toronto with an additional office in Montreal.

Before coming to Du Pont in 1937, Dewey was in charge of the analytical laboratory of the Gulf Research and Development Corporation and supervised a division of its additive research work. He started in the oil industry with Mid-Continent Petroleum Corporation, Tulsa, immediately following graduation from the University of Illinois in 1931 with a bachelor of science degree in chemical engineering.

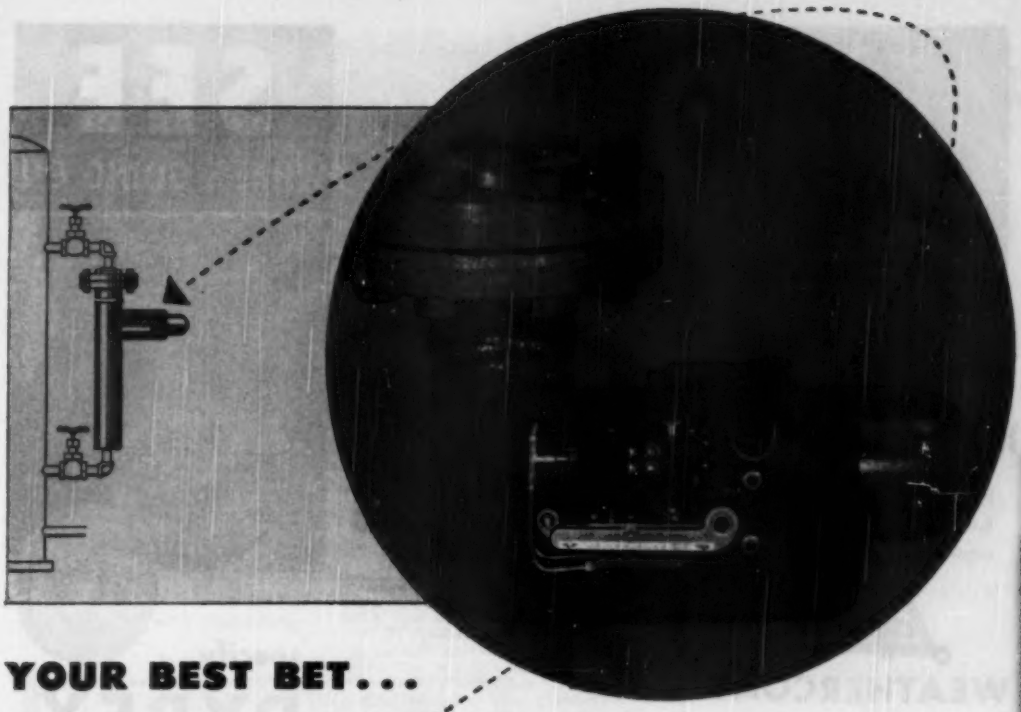
Metal Goods Corporation Buys St. Louis Tract for Building

Metal Goods Corporation has completed purchase of a 10-2/3 acre tract on the southwest corner of Union and Bircher Boulevard, St. Louis, where it will build a modern steel and non-ferrous alloy warehouse, according to Robert E. Grote, president. The building will have inside railroad tracks, parking area, loading docks and metal fabricating facilities and will house the St. Louis sales division and the general offices of the company.

F. T. Richardson Appointed ACF Public Relations Director

F. T. Richardson has been appointed director of public relations of American Car and Foundry Company. He succeeds

How to Reduce
Shutdown Time
In any cooling water system there are scores of places where scale and corrosion can cause trouble and severe damage. Cleaning, maintenance and replacement of condensers, heat exchangers, coolers, piping and other equipment all represent a considerable loss, both in time and money. Losses can be reduced to a minimum, or eliminated entirely, by the proper application and control of treatment chemicals.
BETZ is an organization of engineers and chemists specializing in the solution of all industrial water problems. Over two decades of experience have made Betz water conditioning service scientifically correct, complete . . . economical. Our nationwide staff of engineers will welcome the opportunity of discussing your water problems.
W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa.
BETZ
COOLING WATER CONDITIONING . BOILER WATER CONDITIONING



YOUR BEST BET...

For Liquid Level Measurement In Continuous Processes...

THE HONEYWELL DISPLACEMENT-TYPE TRANSMITTER

TODAY'S continuous processes demand the type of liquid level measurement best provided by this Honeywell Displacement Type Transmitter. Its outstanding features include *unusual sensitivity* (1 part in 5,000), *friction-free design* and *high speed response* (less than 5 seconds, full range).

It affords dependable measurement of many different liquids (Sp Gr 0.3 to 2.0) without changing parts... unaffected by ambient temperatures and vibration. Neither purge nor liquid seals are required. It is easy to clean. It is available in nine operating ranges for level measurements from 0″ to 120″... with connections to suit all usual process vessels. It may be connected to any pneumatic receiver... indicator, recorder or controller... and operates with a full range of transmitted air pressures from 3 to 15 psi.

For more detailed information about this transmitter, call in your local Honeywell engineer... he is as near as your phone! MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 1907 Windrim Ave., Phila. 44, Pa. Offices in more than 80 principal cities of the United States, Canada and throughout the world.

Honeywell

VALVE PRODUCTS

It MUST Be Good!

During the last two years, over 3,000,000 sq. ft. of refinery insulation has been PROTECTED by

Laykold

WEATHERCOAT

It is the accepted protective coating in the refining industry because it —

- TROWELS EASILY —
- DRIES UNIFORMLY —
- STAYS FLEXIBLE YET TOUGH

Also Try —

MASTIC WEATHERCOAT—a new ready-mixed product for easy void-filling scratch coat.

Ask for specifications, data, and performance FACTS.

In the West

STANCAL ASPHALT & BITUMULS COMPANY

200 BUSH STREET · SAN FRANCISCO 4, CALIF.

Los Angeles 14, Calif. · Oakland 1, Calif.
Portland 7, Ore. · Tucson, Ariz.

In the East

AMERICAN BITUMULS COMPANY

200 BUSH STREET · SAN FRANCISCO 4, CALIF.

Washington 6, D. C. · Baltimore 3, Md. · Perth Amboy, N. J. · Columbus 15, O. · St. Louis 17, Mo.
Baton Rouge 2, La. · E. Providence 14, R. I.
San Juan 23, Puerto Rico · Mobile, Ala.

Arthur Tuckerman who is retiring to resume his former profession of free-lance writer.

Richardson came to ACF as public relations assistant in 1947. He was educated at Rensselaer Polytechnic Institute and was employed before World War II in the public relations department of the Illinois Central Railroad in Chicago.

Chris Nitschke Appointed Rockwell's Project Engineer

R. Chris Nitschke has joined Rockwell Manufacturing Company as a project engineer on the company's petroleum products. He formerly was employed by Standard Vacuum Oil Company as assistant chief engineer and from 1941 to 1943, he headed his own consulting engineering operation in New York City which was dissolved when he entered the armed service as a petroleum specialist.

Nitschke

Nitschke spent 1946 in South America as a project engineer for The M. W. Kellogg Company. Just prior to joining Rockwell he was with Arthur G. McKee & Company. He received his basic engineering training at Victoria College in England and after coming to the United States did petroleum engineering work at Columbia University and the University of Tulsa.

GATC Opens Division Office For Plate and Welding at Tulsa

A new plate and welding division office has been opened in Tulsa by General American Transportation Corporation. J. D. Camp will handle sales of all fabricated equipment as well as Wiggins conservation structures and Wiggins gasholders.

Camp, whose office will be in the First National Building, has been a member of General American Transportation's sales force since completing duty in the U. S. Navy.

Livingston Heads McKee's Oil Refining Division Sales

Myran J. Livingston has been appointed to the position of sales manager of Arthur G. McKee & Company's petroleum refining division. Livingston, who will be located at the company's headquarters in Cleveland, for the past six years has been in charge of the company's sales office in New York.

Jerry Brennan, who recently became associated with the company as a sales engineer, will be placed in charge of the New York office. Brennan, formerly, had been the New York representative of Sivyer Steel Castings Company.

Foxboro Company Announces Two Recent Office Openings

Two new branch offices of The Foxboro Company brings the total of the company's domestic offices to 39, three of which include branch factory facilities. The newest branch office at 214 West Tenth Street, Wilmington, Del.,

SEE
WHAT'S GOING ON

specify

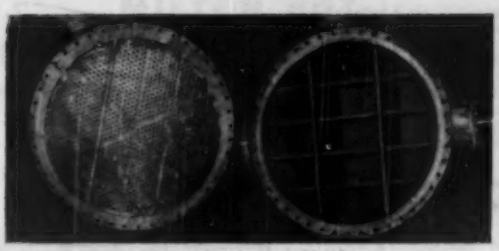
PYREX
BRAND
SIGHT GLASSES

PYREX brand sight glasses provide sharp visibility in safety on such equipment as pressure vessels, stills, reaction kettles, ovens, furnaces, evaporators, etc.

PYREX brand glass gives you three exclusive advantages. (1) Thermal endurance under rapid temperature changes. (2) Chemical resistance to all acids except HF. (3) Transparency throughout long service life.

Call your nearest Warehousing Distributor. He stocks PYREX brand sight glasses, gauge glasses, oil cup and lubricator glasses and MACBETH brand flat gauge glasses.

CORNING
GLASS WORKS
CORNING, N.Y.
PYREX



Superior condenser and head

SUPERIOR-Built for efficient operation!

Superior equipment is manufactured and designed to do a tough, efficient job. Throughout the industry our products are known for their rugged characteristics and for the exacting work and careful attention that go into them. When you want a superior job, call SUPERIOR.

ALSO
FRACTIONATING TOWERS • HEAT EXCHANGERS • SCRUBBERS AND RETUBING OF HEAT EXCHANGERS

API-ASME AND ASME CODE CERTIFIED BY NATIONAL BOARD

For Estimates Call Amarillo 3-4395

SUPERIOR MANUFACTURING COMPANY
AMARILLO, TEXAS

Chemical Refining of Petroleum

By VLADIMIR A. KALICHEVSKY
Research and Development Laboratories, Socony-Vacuum Corpn. Author of "Modern Methods of Refining Lubricating Oils"

and BERT ALLEN STAGNER, Ph.D.
Consulting and Research Chemist; Member, American Institute of Chemical Engineers; Formerly: Supervisor Chemical Research, Union Oil Company of California; Research Fellow, Mellon Institute of Industrial Research

American Chemical Society Monograph, No. 63
Second Edition, Revised and Enlarged

The rapid development of petroleum technology has necessitated a revision of the original volume published in 1933. The newest practice in regard to treatment with sulfuric acid, tetraethyl lead, octane rating, etc., is described in detail. The present emphasis on all phases of this vitally important subject makes this book a particularly timely one, especially since the petroleum problem today is rather one of refining capacity than of crude production. For this reason technical improvements are of the utmost importance for the pressing problems of national defense.

CHAPTERS

Prefaces
Composition of Petroleum
Treatment with Sulfuric Acid
Sulfuric Acid Sludge and Hydrogen Sulfide: Recovery and Manufacture of Sulfuric Acid
Treatment with Alkaline Reagents
Sweetening Operations. Elimination of Elemental Sulfur and Reduction of Total Sulfur in Light Distillates
Chemical Refining of Petroleum
Refining by Adsorption
Refining with Solvents
Detonation and Antidetonants
Inhibitors of Atmospheric Oxidation of Petroleum Products. Gums and Cracked Petroleum Products
Deterioration of Lubricating and Similar Oils. Additional Agents
Supplementary List of United States Patents on Petroleum Refining
Appendix. Special Tables
Patent, Author, Subject Indices

550 PAGES. ILLUSTRATED. PRICE—$8.25

SEND ORDERS TO

THE GULF PUBLISHING COMPANY
P.O. BOX 2608 HOUSTON, TEXAS

D-F S-E*

*EXPANSION JOINTS

The importance of D-F S-E to you may be measured in dollars. Maintenance costs are reduced to a minimum. Initial cost is amortized over a long life. Case histories show BADGER D-F S-E EXPANSION JOINTS installed in the early thirties are still on the job.

D-F S-E could mean *definite financial savings effected*—actually D-F S-E does mean **Directed-Flexing Self-Equalizing.* Directed-Flexing, an exclusive construction feature in Badger Joints, is a combination of an all-curve corrugated member and correspondingly shaped Self-Equalizing rings which not only limits the movement of each corrugation but also progressively controls each increment of movement over the area of each corrugation. This construction eliminates localized stresses which cause metal fatigue and break-downs.

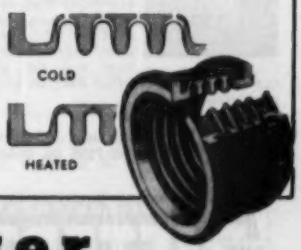
Send today for new 24-page catalog

***All-curve* flexing guarantees longer life**

Badger Joints flex like this . . .

not like this . . .

. . . this stress-free flexing principle exclusive with Badger.



Badger MANUFACTURING COMPANY
230 BENT STREET CAMBRIDGE 41, MASS.

SULFUR and CARBON
Analyses
in
PETROLEUM PRODUCTS

The sulfur content of oils, waxes and greases is an important measure of the value and quality of the product.

Whether the desired sulfur content be high or low, it is necessary to know exactly what amount is present.

The combustion method offers a rapid and sure means of determining sulfur in the wide range of percentages and materials encountered in the oil and grease field.

The Dietert-Detroit Sulfur Determinator embodies the correct principles of the combustion method in a simple, rugged and convenient form. Complete analysis can be made in less than five minutes.

Carbon determinations on organic compounds are being made in as little as two minutes with the Dietert-Detroit No. 3003 Carbon Determinator.

This method can be applied to any petroleum product. One example of the usefulness of this method is the analysis of cracking catalyst for carbon content.

Leading oil companies* are taking advantage of these versatile, time-saving determinators. Write to Dept. P-2 for detailed information on how you can apply rapid carbon and sulfur analysis to your problems.

*Two typical users— THE SHELL OIL COMPANY / THE PURE OIL COMPANY

CONTROL EQUIPMENT
HARRY W. DIETERT COMPANY
9330 ROSELAWN • DETROIT 4, MICH.

is under the managership of Kenneth L. Barton, who has been with Foxboro for 25 years.

Earlier this year an office was opened at 225 South Fifth Street, Minneapolis 2, Minn., with Robert C. Cahill as Resident Engineer. Foxboro interests in that area have been represented in the past by a firm of engineers.

McFarland Manufacturing Names Clarke A. Polk Sales Manager

Clarke A. Polk, formerly assistant general manager of Sterling Packing and Gasket Company has been appointed sales manager of McFarland Manufacturing Corporation, Houston, manufacturers of chemical injectors, hydrostatic testing pumps and blowout preventer closing units.

Polk

Polk started in the oil industry in 1933 as a "bit hustler" for a Houston machine shop, this after three years at the University of Oklahoma. He joined Well Equipment Company and worked for them until 1938, during this tenure having opened Weco's California territory. During the war he left Sterling for a time in order to do special research work for the military but returned to stay with them until he took the present post with McFarland.

Sier-Bath Gear and Pump Appoints New Representatives

Representatives for Sier-Bath gear coupling recently appointed by Sier-Bath Gear and Pump Company of North Bergen, N. J., are J. R. Ruddock & Associate of 7001 North Clark Street, Chicago; the Volco Company, 622 McKnight Building, Minneapolis, and the W. B. Conrad Company, 506 Curtiss Building, Detroit 2.

J. R. Ruddock and associates will have as their territory Northeastern Illinois, including the Chicago metropolitan area and bordering counties in Michigan. The Volco Company will serve Minnesota, Iowa, South Dakota, North Dakota, Northwestern Illinois and the Peninsula of Michigan.

The W. B. Conrad will have the southeastern Michigan territory.

Sorlie Company to Represent De Laval Steam Turbine Sales

De Laval Steam Turbine Company, Trenton, N. J., has appointed R. M. Sorlie Company of Kalamazoo, Mich., as sales representative for the western half of the lower peninsula of Michigan.

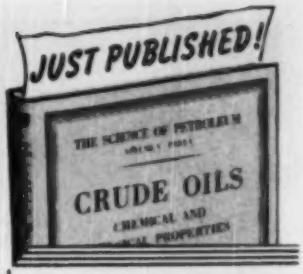
De Laval also has appointed Robert F. Curry, specialist in the power transmission field, to the office in Detroit. Curry is a member of the Engineering Society of Detroit.

Ralph Mumert Joins Edward West Coast Representative

Ralph A. Mumert has been appointed a sales engineer with F. J. Hearty & Company of Los Angeles and San Francisco, west coast representative for Edward Valves, Inc., East Chicago, Ind.

Mumert was formerly associated with

JUST PUBLISHED!



VOLUME V • PART 1
The Science of Petroleum

Crude Oils

Chemical and Physical Properties

Edited by
B. T. BROOKS, PH.D., *New York, and*
A. E. DUNSTAN, D.SC., *London*

A comprehensive and completely up-to-date volume dealing with the Chemistry, Physics, and Chemical Engineering of Petroleum.

Contents

Section I. **CRUDE OILS**

The Crude Oils of the U. S. A., H. M. SMITH. The Crude Oils of Venezuela, GULF REFINING COMPANY. The Crude Oils of Saudi Arabia, ARABIAN-AMERICAN OIL COMPANY. The Crude Oils of Bahrein Island, J. R. KEITH. The Crude Oils of the Middle East, D. A. HOWES and L. C. STRANG. Evaluation of Crude Oils and Oil Stocks, W. L. NELSON. Economic Developments in the Petroleum Industry, O. TOKAYER.

Section II. **CHEMICAL AND PHYSICAL PROPERTIES OF PETROLEUM HYDROCARBONS**

Hydrocarbons in Petroleum. A. W. SACHANEN. The Chemistry of Paraffin Hydrocarbons, J. HABESHAW. The Chemistry of Naphthene Hydrocarbons, W. J. OLDHAM. The Chemistry of Aromatic Hydrocarbons, W. J. OLDHAM. The Chemistry of Olefine and Diolefine Hydrocarbons, F. A. FIDLER. Mechanism of Organic Reactions, F. G. WHITMORE and N. C. COOK. The Fractionation, Analysis and Isolation of Hydrocarbons in Petroleum, B. J. MAIR and F. D. ROSSINI. Chemical Thermodynamic Properties of Hydrocarbons, F. D. ROSSINI. High Pressure Vapour-Liquid Equilibria in Cycling Operations, D. L. KATZ and M. J. RZASA.

Illustrations, diagrams, tables and index. $11.00

Write for free circular

OXFORD UNIVERSITY PRESS
114 FIFTH AVE., N. Y. 11, N. Y.

MILTON ROY CHEMICAL FEED SYSTEMS

At Stanolind Oil Co., Hastings, Texas.

- **For Pumping Inhibitors**
- **Water Treating Chemicals**
- **Light Hydro-Carbons**
- **Heavy Viscous Materials**

Milton Roy Chemical Feed Systems are widely applicable in operations where precise volume control is a requirement. They have been successfully employed in industrial waste treatment, chemical processing operations, automatic pH control, boiler water chemical treatment, etc., and in converting from batch to continuous processing methods.

Since variation in discharge pressure of the Milton Roy Controlled Volume Pump used in these systems has no effect upon volume delivered, capacity is a direct ratio to the speed of the operation. Thus, with a change in the speed effected by manual or automatic controls, an immediate proportional change in the delivered chemical flow is assured. Any metered variable such as pH value, temperature, pressure, flow, conductivity, liquid level or any other can be used to automatically actuate the system.

Milton Roy engineers and furnishes controlled volume pumps and necessary meters, actuating devices and controls for automatic feed systems.

Write for latest literature.

MILTON ROY COMPANY
1315 E. MERMAID LANE, CHESTNUT HILL, PHILA. 18, PA.

99%

CATALYST RECOVERY?

Research Corp. Engineer: Yes sir. Actual operating experience with our Cottrell precipitators shows recoveries as high as 99.6% of fluid catalyst.

Refinery Executive: What about draft loss?

Research Corp. Engineer: It's extremely low —only a few tenths of an inch of water.

Refinery Executive: Do you actually guarantee performance?

Research Corp. Engineer: Absolutely. And you can depend on a Research Corporation guarantee because of Research Corporation's 38 years experience in electrical precipitation.

RC 150

RESEARCH CORPORATION

405 Lexington Avenue, New York 17, N. Y.
122 South Michigan Avenue, Chicago 3, Illinois

SIER-BATH
SCREW PUMPS
solve the toughest
Pumping Problems!

Take a tough, sticky pumping problem — add powerful Sier-Bath Screw Pumps—and you've got the recipe for a smooth-flowing operation! Simple design (only two moving parts), and sturdy but accurate construction are Sier-Bath's formula for efficient, low cost moving of viscous materials.

SIER-BATH SCREW PUMP

Pumps acetates, asphalts, brines, Bunker C fuel oil, cellulosics, greases, molasses, syrups, etc. Pressures up to 1000 lbs.

These Features Cut Maintenance Costs:

1—*No metallic contact between rotors* sustains high volumetric efficiency, even when handling non-lubricating liquids.

2—*High volumetric efficiency* reduces wear caused by erosion.

3—*Axial Flow from ends to center* eliminates thrust bearings, high radial loads, pulsation, vibration.

4—*Only suction pressure on stuffing box*—packing can be added while pump is running.

5—*Heavy duty service* from husky shafts, sturdy rotors, high load capacity bearings, and deep stuffing boxes.

Available in horizontal or vertical construction—special alloys, jacketed bodies to meet individual requirements. Write for booklet.

ALSO MANUFACTURERS OF "GEAREX" ROTARY PUMPS, PRECISION GEARS, and GEAR COUPLINGS.

FOUNDED 1900 MEMBER A.G.M.A.

Sier-Bath
GEAR and PUMP CO., Inc.
9249 HUDSON BLVD., NORTH BERGEN, N. J.

Keenan Pipe and Supply Company. He attended the University of South Dakota and Northwestern University, and was an officer in the U. S. Naval Air Forces.

Byron Jackson Names Thomas As Houston Branch Manager

William S. Thomas has been appointed branch manager of the Houston office of the Pump Division, Byron Jackson Company. Previously he was branch manager of BJ's San Francisco office.

Thomas

Thomas is a graduate of the University of California at Berkeley and of the Harvard School of Business. He started with Byron Jackson in July, 1941, and three years later was made submersible motors production manager in Los Angeles. He held this position until 1946 when he became a sales engineer. He was appointed branch manager at San Francisco in 1946, managing the sales of BJ pumps in the northwestern states.

American Cyanamid's New Plant Relocated in Michigan City

American Cyanamid Company's new $3 million plant for the production of cracking catalysts used by the petroleum industry, originally scheduled for construction in East Chicago, Ind., will be built in Michigan City, Ind. Although a site had been purchased in East Chicago, the company has decided to locate on a larger site in Michigan City.

Hammel-Dahl Appoints Tragard And MacDonald Vice Presidents

Hammel-Dahl Company has appointed John O. Tragard, vice president in charge of sales and contracts, and Maurice MacDonald, vice president and manager of engineering.

Tragard was employed for 20 years with The Foxboro Company as sales executive and legal counsel and 4 years with Fulton Sylphon Division of Robertshaw-Fulton Controls. A graduate of Northeastern University and Harvard College, he was admitted to the Massachusetts Bar in 1936.

MacDonald has been with Johns-Pratt Company and Bussman Company of St. Louis. In 1932 he joined The M. W. Kellogg Company and has been chief engineer in charge of instrumentation and control for the past eight years.

Weingard Is Named Production Manager of American Meter

American Meter Company has named Archie E. Weingard manager of production, headquarters at the Erie plant.

Weingard first became associated with American Meter in 1947 as supervisor of methods, later being made assistant to the vice president. His new appointment will broaden his responsibilities to include production, methods, planning, and scheduling, as well as the supervision and setting up of advanced systems and manufacturing procedures.

Weingard is a graduate of the General

anti-corrosive
strapping and seals

Our specialized service will supply just what you need for securing insulation to forms, pipe lines and tanks. Strapping and Seals produced in

MONEL
STAINLESS, TYPES 304, 316
ALUMINUM
COPPER
BRASS
GALVANIZED

Strapping Tools for applying.

FREE
Handy calculator—one side tells you which strap to use for any given corrosive condition; other side determines length and weight of strap required for any binding operation.

A. J. Gerrard & Co.
1936 Hawthorne Ct., Melrose Park, Ill.
(Chicago Suburb)
SM-2

industrial
OIL AND GAS BURNING EQUIPMENT

- Mechanical Atomizing Oil Burners
- Steam Atomizing Oil Burners
- Refractory Burner and Muffle Blocks
- Industrial Gas Burners
- Low Air Pressure Oil Burners
- Fuel Oil Pump Sets
- Valves, Strainers, Furnace Windows
- Tandem Block Combustion Units
- Combination Gas and Oil Burners

Detailed information gladly sent you upon request.

NATIONAL BURNER

NATIONAL AIROIL BURNER COMPANY, INC.
1234 E. Sedgley Ave.,
Philadelphia 34, Pa.
Southwestern Division: 2512 So. Blvd., Houston 6, Tex.

Whenever you see furnaces like these you can be sure they're Petro-Chem Iso-Flow* design

More than 652 are in satisfactory operation throughout the world in the petroleum and allied industries... for all processes and for any capacity.

*Reg. U. S. Pat. Off.

PETRO-CHEM ISO-FLOW FURNACES

UNLIMITED IN SIZE · CAPACITY · DUTY

PETRO-CHEM DEVELOPMENT CO., INCORPORATED

120 EAST 41ST STREET, NEW YORK 17, N. Y.

Representatives: Bethlehem Supply Co., Inc. and Hoeller, Engr. Research & Sales, Allentown, Pa. Foster Wheeler Corp., Engineers & Constructors, New York, Chicago, Houston, Los Angeles, San Francisco

There's a Petro-Chem Iso-Flow Furnace and Boiler for every service, capacity or duty, irrespective of temperature, pressure ranges . . . none too small or too large . . . more than 652 in operation throughout the world in the petroleum and allied industries, performing with utmost satisfaction . . . and in many instances operating in excess of their design capacity by more than 50%.

Shaft Packing No Chemical Can Attack

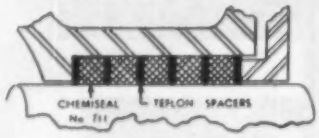
Teflon "Chemiseal" #711 Packing Stays in Service Months Where Other Packings Failed in Hours

"We've got a pump handling hypochlorites," a paper manufacturer told us, "and we can't find a packing that will last more than 5 hours." So we sent him a set of Chemiseal #711. It went into continuous service in November. It's still in there and going strong months later.

A steel plant tried a #711 packing last summer on a pump handling coke liquor. Recently they ordered #711 for 40 more pumps.

There are hundreds of similar cases in our files.

CHEMISEAL #711 SHAFT PACKING



CHEMISEAL #711WX SHAFT PACKING

No chemical — acid, solvent, caustic, oil or gas—can attack or dissolve a Teflon Chemiseal #711 or #711WX packing. "Chemiseal" non-corroding, non-contaminating, heat-resisting gaskets, packings, adapters and expansion joints can save you hundreds of dollars and countless production delays.

Phone, write or bring your gasket and packing problems to —

UNITED STATES GASKET CO.

682 N. 10th Street
Camden, New Jersey

Electric Technical Engineering School, where he studied engineering, designing, management and analytic subjects. Following his graduation he spent 16 years at General Electric, serving as foreman of a general machine department, chief planner and tool planner, supervisor of railway control planning and wage payment division.

Edwards Valves Names Carr Engineering-Research Head

Laurence H. Carr has been named director of engineering and research for Edward Valves, Inc., East Chicago, Ind. Carr has been a member of the Edward technical staff since 1936. He was previously chief metallurgist. In his new position, he will be responsible for consolidating the development functions of engineering research, product engineering and technological specifications for process control.

Carr

Carr, a graduate of the University of Chicago, is a member of ASME, ASM, AIME and other professional societies.

Marley Company Appoints

Roy W. Maze has been appointed merchandising sales manager of The Marley Company, Inc. He has been public relations director of the company since 1946.

A native of Kansas City, Maze re-

WIRE MESH

Maybe it all *does* look pretty much the same at first glance. But when a firm has been making wire mesh for 70 years man and boy, there's bound to be a little more to it than meets the eye —a little more know-how in engineering and weaving, a little more quality in the product, a little more service and satisfaction to the user.

JELLIFF WIRE MESH is woven in all ductile metals
JELLIFF WIRE MESH is woven in all commercial weaves
JELLIFF WIRE MESH is woven in widths up to 72 inches

JELLIFF WIRE MESH is economical. Every foot runs true to the specifications.

JELLIFF WIRE MESH is a quality product and has been for 70 years. You can depend on it.

Write today for full details about JELLIFF WIRE MESH, JELLIFF WIRE-MESH PRODUCTS, and JELLIFF'S CONSULTATION SERVICE on wire-mesh engineering. Address Department 16.

ceived his A.B. degree from the College of Emporia and an M.S. from Kansas State College. After five years of teaching and administrative work in high schools, he joined the engineering department of Aireon Corporation in 1942 and remained with it until enlisting in the Army.

Carr Moves to Shreveport As Dowell District Manager

Orlin W. Lyons, district manager for

Lyons

Carr

Dowell Incorporated at Shreveport for the past seven years, has accepted a position on the management staff of Brazos Oil and Gas Company, Houston. Floyd Carr, development engineer for Dowell Perfo-Jet Services in the Tulsa general offices, has been appointed district manager of Shreveport.

Lyons has been with Dowell since August, 1936. He was a research engineer in Tulsa until his appointment as Shreveport district manager in 1943.

Carr, a graduate in petroleum engineering from the Colorado School of Mines, joined Dowell in 1939 and has been Perfo-Jet development engineer in Tulsa since February, 1949.

Smith Resigns as President Of Black, Sivalls & Bryson

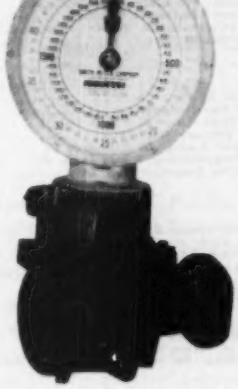
The resignation of A. J. Smith as president and director of Black, Sivalls & Bryson, Inc., has been accepted and Kenneth W. Lineberry, a member of the board of directors since 1946 and chief executive officer for the past few weeks, has been elected president.

Lineberry has resigned as vice president and director of F. S. Yantis & Company, with which he has been associated for the past seventeen years.

Vulcan Rubber Names McConnell

Vulcan Rubber Products, Inc., Brooklyn, has appointed Thomas H. McConnell, Jr., as sales promotion and advertising manager of the company, in charge of all new business. McConnell, who joined the company in 1948, was formerly with Standard Oil Company (New Jersey) and Standard Vacuum Oil Company, when he traveled in Europe, Africa and Asia as an aviation representative.

FLUID METER



Manufactured by Smith Meter Co., Los Angeles. For metering of crude oil, gasoline, diesel oil, etc.

Dial registers up to 2,000 gallons. Counter registers up to 9,999,999 gallons. Equipped with dial and counter reset lever.

Meter working capacity 50 PSI and 100 GPM. 2" flange connection. Heavy cast aluminum dial and body.

Meters are used but reconditioned and sold with money back guarantee of satisfaction. Weighs 60 lbs. Government cost over $200.00. **Your cost only $34.50 FOB. Tulsa.**

Write for catalog covering over 5,000 pressure gauges made by Marsh, U. S. Gauge, Ashcroft, etc. Available at a fraction of your current cost.

MIKE A. TRAVIS

101 West Archer Tulsa, Oklahoma

PETROLEUM REFINER CLASSIFIED ADS

RATES for Classified Ads are $4 per column inch. Minimum size one column inch. In smallest type size, figure 50 words per inch. **Situations Wanted** $2 per column inch. **All classified ads payable in advance.** Ten percent discount if three or more insertions are ordered at same time. COPY DEADLINE is 25th of month preceding date of issue. Send copy and checks to: Classified Ad Department, Petroleum Refiner, P. O. Box 2608, Houston 1, Texas.

* * * * * * * * * * * * * * * * *

New Small Oil Refinery in Bolivia, S. A., Requires Experienced Personnel as Follows for One Year with Opportunity Renewal Contract. Salaries Paid in U. S. Funds.

CHIEF CHEMIST: Graduate chemical engineer minimum three to five years' refinery experience including control laboratory work and technical service in plant operations especially light ends and aviation gasoline blending.

CHIEF OPERATOR: Minimum five years' all-round refinery experience particularly with precise fractionation including operating foreman experience; capable directing refinery utility services. Graduate chemical engineer preferred.

OPERATORS: Experienced shift operators capable supervising plant and utilities operations especially precise fractionation; general overall refinery experience necessary.

OCTANE TESTER: Thoroughly experienced routine methods and maintenance on aviation gasoline knock-testing engine.

INSTRUMENT MAN: Thoroughly experienced capable assuming responsibility of instrument dept.

Box 180-R, c/o Petroleum Refiner, Houston, Texas

FOR SALE

STEEL STORAGE TANKS

Available Immediate Delivery

2—118,000 bbl. Steel Cone Roof
6— 80,000 bbl. Steel Cone Roof
6— 55,000 bbl. Steel Cone Roof
3— 37,500 bbl. Steel Cone Roof
3— 25,000 bbl. Steel Cone Roof
2— 16,000 bbl. Steel Cone Roof
11— 11,000 bbl. Steel Cone Roof

Smaller additional tanks, 850 bbl. to 7500 bbl. inclusive, available same location.

All tanks now standing Texas Company's refinery site, Dallas, Texas, suitable for re-erection.

Additional information regarding prices, specifications, etc., available upon request.

Mid-States Pipe & Supply Co.

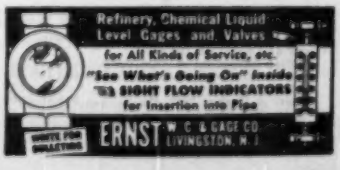
Ph. 2-9128 Tulsa, Oklahoma

Young, married man (32), (one child), desires position in oil or chemical industry, supervisory or ass't supervisory status. Have fourteen years experience as job leader, squad boss, designer, layout and detail of piping & pressure vessels. Will relocate in Continental U. S. Resume and references upon request. Address Box 183-R, % Petroleum Refiner, Houston, Texas.

Project Engineer

Prominent Engineering and Construction Company, located in New York City, requires Project Engineers to coordinate and direct engineering work in connection with the design and construction of petroleum and chemical plants. M.E. or Ch.E. graduate with practical petroleum refinery engineering and construction experience required. Position is permanent with excellent promotional opportunities. Detailed resume of experience and photograph desired at Box 181-R, % Petroleum Refiner, Houston, Texas.

Registered Engineer, headquarters Chicago, with 26 years experience all phases petroleum industry, ten of which has been connected with liquefied petroleum gas, desires to represent equipment or process manufacturers. Address Box 182-R, % Petroleum Refiner, Houston, Texas.


Refinery, Chemical Liquid Level Gages and Valves
for All Kinds of Service, etc.
"See What's Going On" Inside
"ES SIGHT FLOW INDICATORS
for Insertion into Pipe
ERNST GAGE CO.
LIVINGSTON, N. J.

ADVERTISERS

in the October, 1950, issue of

Petroleum Refiner

* The asterisk preceding name of advertiser indicates that detailed data on products and services of the firm will be found in The 1950 Refinery Catalog.

A

*The Air Preheater Corp. 45
*Airetool Manufacturing Co. 178
*Allied Chemical & Dye Corp. 38
*Allis-Chalmers Manufacturing Co. 9
*Alloy Steel Products Co. 146
*Aluminum Company of America ..... 14, 77 and 204
The American Brass Co. 67
American Bitumuls Co. 222
American Cyanamid Co. 36-37
*American Locomotive Co. 157
American Smelting & Refining Co. 215
*Armstrong Machine Works 5
*Attapulgus Clay Co. 137

B

*The Babcock & Wilcox Co. ..... 6 and 201
*E. B. Badger & Sons Co. 16-17
*Badger Manufacturing Co. 223
*Bailey Meter Co. 170
Baker & Adamson Products
General Chemical Division
Allied Chemical & Dye Corp. 38
*Baldwin-Hill Co. 191
W. H. & L. D. Betz 220
*Black, Sivalls & Bryson, Inc. 31
*Blaw-Knox Co. ..... 200 and 212
*Born Engineering Co. 70
Bridgeport Brass Co. 81
The Bristol Co. 7
*The Brown Fintube Co. 197

C

Calumet & Hecla Consolidated Copper Co. 181
The Chapman Valve Manufacturing Co. 195
Chase Brass & Copper Co. 175
*Chemical Construction Corp. 170
Chicago Bridge & Iron Co. 27
Childress Manufacturing Co. 74
The Clark Manufacturing Co. 190
Classified Advertising 229
*Corning Glass Works 222
*Crane Co. 2
*Croll-Reynolds Co. 213

D

*Dean Brothers Pumps Inc. 158
Harry W. Dietert Co. 224
Dowell Incorporated 58
Dresser Industries, Inc. 155
E. I. du Pont de Nemours & Co. 48-49
*The Dumbey Co. 182

E

*The Eagle-Picher Co. 10-11
*Elliott Co. ..... 139 and 190
*Ernst Water Column & Gage Co. 220
Ethyl Corp. 68-69

F

Federated Metals Division
American Smelting & Refining Co. 215
*Fisher Governor Co. 22
*Flint Steel Corp. 198
*The Flour Corp. 73
*Foster Wheeler Corp. ..... Insert 192-193
The Foxboro Co. 82

G

*The Garlock Packing Co. 189
*General American Transportation Corp. 169
*General Chemical Division
Allied Chemical & Dye Corp. 38
*General Electric Co. ..... 12-13 and 164-165
A. J. Gerrard & Co. 226
Gilbert & Barker Mfg. Co. ..... 152 and 200
*The Girdler Corp. 78
*Grinnell Co. 42
*The Gulf Publishing Co. 223

H

Hagan Corp. 55
*Hamer Oil Tool Co. 174
Hammel-Dahl Co. 217
The Hays Corp. 52
A. L. Henderer's Sons 214
Hoke, Inc. 214

I

*Industrial Division
Minneapolis-Honeywell
Regulator Co. ..... 25 and 221
*International Engineering, Inc. 172
The International Nickel Co. 167

J

The C. O. Jelliff Mfg. Corp. 228
*Johns-Manville ..... 32 and 142
*The Johnston & Jennings Co. 210

K

Kaylo-Division
Owens-Illinois Glass Co. 19
*Kennedy & Mattison Co. 44
*The M. W. Kellogg Co. ..... Insert 32-33 and 162
*The C. M. Kemp Mfg. Co. 211
Kinney Manufacturing Co. 190
*Klingerit, Inc. 218
*The Koch Engineering Co. 161

L

Layne & Bowler, Inc. 213
*Leeds & Northrup Co. 8
Lukens Steel Co. 187
*The Lummus Co. 43
The Lunkenheimer Co. 232

M

Maintenance Engineering Corp. 30
Manning, Maxwell & Moore, Inc. 30
*Mason-Neilan Regulator Co. ..... 15 and 183
The Master Electric Co. 26
*A. Y. McDonald Mfg. Co. ..... Cover IV
McNamar Boiler & Tank Co. 207
Metal Textile Corp. 171
*Midwest Piping & Supply Co. 206
*Milton Roy Co. 225
*Minneapolis-Honeywell
Regulator Co. ..... 25 and 221
Mundet Cork Corp. 196
*Murray Iron Works Co. 216

N

The Natusco Co. 203
*National Airoil Burner Co. 226
*National Carbon Co. 176
National Lead Co. 148
*W. H. Nicholson & Co. 208
*Nooter Corp. 62
*Nordstrom Valve Division
Rockwell Manufacturing Co. 28-29
*W. C. Norris, Manufacturer, Inc. 46

O

*Oakite Products, Inc. 192
Owens-Illinois Glass Co. 19
Oxford University Press 224

P

*Page Steel & Wire Division
American Chain & Cable Co. 41
*The Paraffine Companies, Inc. 186
*Perco Division
Phillips Petroleum Co. 54
*Petro-Chem Development Co. 227
Petroleum Chemicals Department
American Cyanamid Co. 36-37
*Phillips Petroleum Co. 54
Philadelphia Gear Works, Inc. 34
Posey Iron Works, Inc. 202
The Wm. Powell Co. 145
*The Prressed Steel Co. 151
*J. F. Pritchard & Co. ..... 35 and 215

R

Reading-Pratt & Cady Division
American Chain & Cable Co. 53
Refinery Supply Co. 60
Republic Flow Meters Co. 150
Republic Steel Corp. ..... 18 and 185
*Research Corp. 225
*Revere Copper & Brass Inc. 231
The Ric-Wil Co. 51
*The Ridge Tool Co. 205
*Rockwell Manufacturing Co. 28-29
*Rockwood Sprinkler Co. 30
*Roots-Connersville Blower Corp. 155
Rust-Oleum Corp. 184

S

Shand & Jurs Co. 40
Shell Development Co. 47
Sier-Bath Gear & Pump Co. 226
The Edward Soph Co. 215
Stancal Asphalt & Bitumuls Co. 222
*Sun Shipbuilding & Dry Dock Co. 20
Superior Manufacturing Co. 223

T

*Taylor Forge & Pipe Works 173
*The Terry Steam Turbine Co. 141
The Timken Roller Bearing Co. 4
Mike A. Travis 229

U

*Union Asbestos & Rubber Co. 24
*Union Carbide and Carbon Corp. 176
United States Gasket Co. 228
Universal Oil Products Co. ..... 56-57 and 228

V

Visco Products Co. 3
*Henry Vogt Machine Co. 64
J. H. H. Voss Co. 200

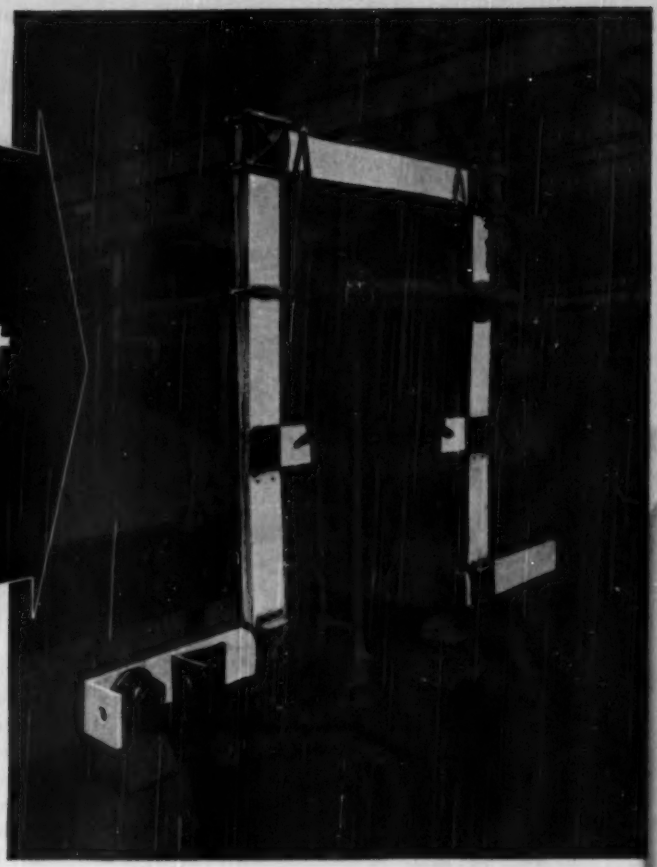
W

Wall Colmonoy Corp. 189
*Wallace & Tiernan Products, Inc. 33
Walworth Co. 23
Warren Petroleum Corp. ..... Cover I
*Watson-Stillman Co. 154
Wedgeplug Valve Co. 210
Weil Equipment Mfg. Corp. 180
*The Whitlock Manufacturing Co. 219
Willson Products, Inc. 166
Thomas C. Wilson, Inc. 219
Wolverine Tube Division
Calumet & Hecla Consolidated
Copper Co. 181
*Worthington Pump & Machinery Corp. 21
Wyatt Metal & Boiler Works ..... Cover III

Y

*Yarnall-Waring Co. ..... Cover II

HIGH efficiency at LOW voltage



Revere Copper is the ideal commercial metal where low voltage D.C. must be conducted at high efficiency.

• Type S, the large Hooker Electrolytic Caustic-Chlorine Cells, operate 24 hours a day 365 days a year at very high current efficiency under average operating conditions.

In the plant of the Hooker Electrochemical Company, at Niagara Falls, N. Y., the current for these cells enters as high voltage A.C. and is converted to low voltage D.C. in mercury arc rectifiers. Revere Copper Bus Bar carries the D.C. current from the mercury arc rectifiers to the Caustic Chlorine Cells. In these high voltage circuits efficiency is promoted by the ability of electrolytic copper to conduct current with the lowest losses possible for any commercial metal. Copper also is the best dissipator of the heat which accompanies high voltage A.C. conduction.

Current of 10,000 amperes from the rectifiers produces a voltage drop of 3.75 per cell. Here any increase in the resistance of the material of which the bus bars are made must result in a corresponding decrease of the efficiency of the circuit.

That is why Revere Electrolytic Copper Bus Bars are used. They have low resistance and high efficiency.

When an anode is to be renewed the cell is short circuited by means of a portable jumper which consists of copper connections and a switch, thus flowing the entire current around the cell and avoiding interruptions of the circuit.

This is an example of the all around handiness of Revere Copper for handling electricity. Copper has ideal mechanical strengths or "physicals" for clamping or bolting, and the best surface for high efficiency connections.

For low voltage or high, make your next installation with Revere Copper Bus Bar. You will get more results from your power dollar.

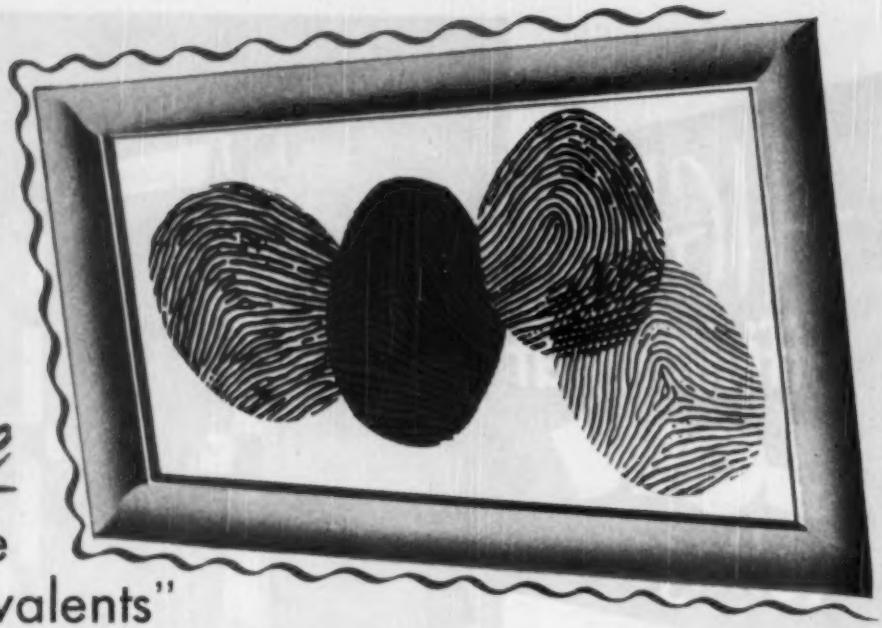
REVERE

COPPER AND BRASS INCORPORATED

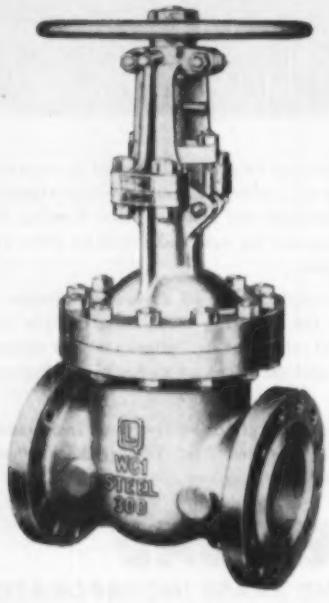
Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.



are there "equivalents" to **LUNKENHEIMER** STEEL VALVES?



Well, there are "alternates." But the engineer's familiar specification, "Lunkenheimer Figure 1938 or equivalent," invites a comparison with your thumbprint — and your neighbor's. How "equal" can valves really be? A few characteristics can *almost* be matched. But there is no equal for most Lunkenheimer features. Consider the metal quality of Lunkenheimer steel castings. Their soundness is unparalleled in the valve field. Lunkenheimer metallurgical research has uncovered whole new areas of study, developed exclusive alloys, pioneered in methods of quality control. The amazing records of safety and long service life achieved by Lunkenheimer steel valves are evidence that there *is* no real equivalent for Lunkenheimer metal quality. In workmanship, too, the famous Lunkenheimer tradition of care and precision has never been equalled. New machines (most of Lunkenheimer's machinery is less than three years old) are making possible *even higher* standards of workmanship. The *only* equivalent to a Lunkenheimer steel valve is another of the same design —a Lunkenheimer. For the address of your nearest representative, and for more steel valve data, write to The Lunkenheimer Co., P. O. Box 360G, Cincinnati 14, Ohio.

STEEL . . . IRON . . . BRONZE

LUNKENHEIMER

THE ONE *Great* NAME IN VALVES

wyatt's
HOUSTON-DALLAS-NEW YORK-TULSA

SAVES 2 to 8 BARRELS OF GASOLINE FOR EACH CAR LOADED

Time-Tested Universal Gastite Dome Cover Offers *Positive Assurance* of Important Reduction in Loading Losses—Belongs in Any Economy Program

Plate 864—Universal Gastite Dome Cover

Reduces Evaporation Losses

•

Removes Danger of Sparks

•

Permits Loading Rain or Shine

•

A Type for Every Car

•

Handled by One Man

For a quarter-century user after user of the Universal Gastite Dome Cover has reported the same results—savings that range from *two* to *eight* barrels per car loaded . . . savings that pay for the cover in jiffy-quick time and continue to return handsome dividends for years.

Furnished to fit any make of tank car, round or oval shape opening. May be used with pop valve on outlet to permit loading under slight pressure—or vapors may be carried back for absorption or compression. Loading pipe may be attached to under side of cover to permit under-surface loading. Equipped with two 2" shut-off valves—loading valve can be furnished larger than 2" if desired. Peep-hole glasses give view of contents while loading. Aluminum construction—weighs only 60 lbs.

Here is a *sure* way to save in a period of economy. Write for full details of the Universal Gastite Dome Cover.

A. Y. McDONALD MFG. CO.

The Home of the Swing Joint

DUBUQUE, IOWA

There's a McDonald Branch or Distributor Near You

McDONALD